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AD 385725

Incendiary Effectiveness Test of Chemical Fireball Munition (U)

by

John R. Kidd, 2d Lt, USAF

SEPTEMBER 1967

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INCENDIARY EFFECTIVENESS TEST OF CHEMICAL FIREBALL MUNITION (U)

by
John R. Kidd, 2d Lt, USAF

FOREWORD

(U) This test, APGC Project 670AW40, was authorized by ADO 45, Part VII, and Air Force Armament Laboratory (ATCC) letter, dated 20 September 1966, and letter of revision dated 31 October 1966. Physical testing was started on 24 March 1967 and was completed on 9 June 1967. This report contains classified information extracted from other classified documents as referenced.

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(U) The following key persons were associated with the testing accomplished under this project and/or preparation of this report:

Project Engineers (APGC)	John R. Kidd 2d Lt, USAF
	Gordon G. Davis, Capt, USAF
Development Engineer (AFATL)	George E. Grant, Capt, USAF

(U) This technical report has been reviewed and is approved.

A. J. KINNEY, Major General, USAF
Commander

CONFIDENTIAL ABSTRACT

(C) This test was conducted to determine the incendiary effectiveness of the chemical fireball munition. A total of 48 munitions were tested. Eleven munitions were detonated singly, 10 in [illegible]irs, and 27 in triple firings. Thirty-nine munitions were detonated at ground level and seven were detonated 4 feet above ground level. Two munitions did not function. The chemical fireball munition caused burning effects on targets simulating personnel and equipment at an average distance of 15.68 feet from the point of detonation when detonated at ground level and 18.08 feet when detonated 4 feet above ground level. This difference is statistically significant at a 99 percent confidence level. The average effective burn area for 32 separate chemical fireball munitions detonated at ground level was 557.9 square feet. The average effective burn area for seven separate chemical fireball munitions detonated 4 feet above ground level was 699 square feet. Effective burn areas are illustrated for each test. Data on thermal radiation for the single firings are included.

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CONTENTS

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Figure

SECTION I

INTRODUCTION

(C) The chemical fireball munition is a thermal radiation weapon designed to produce effects ranging from temporary incapacitation to severe casualties among exposed personnel. Personnel and objects within the effective range of coverage would be exposed to a radiation intensity delivered over a 1/10- to 1-second time period. Effects would depend upon the distance of personnel from the point of ignition and could include skin burns, ignition of clothing and hair, flash blindness, and damage to personal equipment. In contrast, flame fuel weapons depend on long contact of the burning agent with the target to obtain the desired effect.

(U) The specific objectives of this project were to determine:

a. Burn effects on various materials of military importance.

b. Effective burn area (area where a minimum of second degree burns will be experienced).

c. If the effect of the munition is additive, i.e., if the scaling curve is linear for a simultaneous firing of two or more test munitions.

d. Thermal radiation emitted and shock waves at the perimeter of the burning cloud.

(U) All of the above objectives were attained and are reported herein.

SECTION II

DESCRIPTION

(C) The chemical fireball munition (Figure 1) is 10 inches long, 4 1/2 in diameter, and weighs 12.5 pounds. It consists of a cylindrical pressure vessel filled with a fuel mixture and fitted with an axial explosive opening and igniting charge. The fuel is a slurry of aluminum powder (70 percent by volume) in liquified propane. The explosive opening charge is a column of tetryl pellets, surrounded by a concentric column of white phosphorus. The tetryl pellets serve only to rupture the container. The white phosphorus serves as the igniter for the fuel mixture.

(C) The explosive opening charge, when fired, ruptures the walls of the containing vessel. As the normal vapor pressure of the propane is vented upon rupturing of the vessel, the propane flash-evaporates, providing a driving force to disseminate the aluminum powder into a combustible cloud. The propane also serves as an easily ignitable vapor to trigger the combustion of the aluminum. The detonation of the explosive opening charge additionally drives a multitude of phosphorus fragments through the expanding propane-aluminum cloud. Ignition occurs as the phosphorus passes into portions of the fuel cloud which have mixed sufficiently with air to permit combustion. Normally, ignition occurs at a number of points and spreads rapidly through the entire cloud.

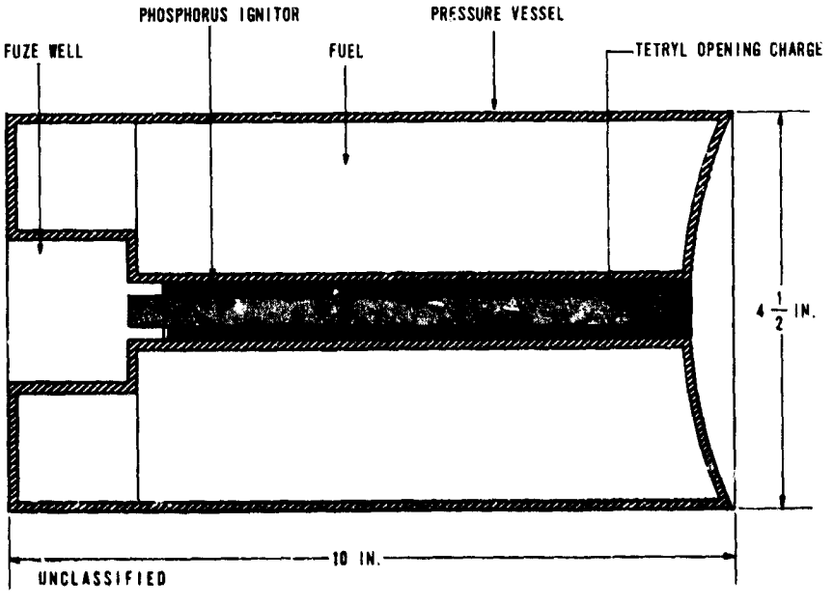

Figure 1. Chemical Fireball Munition.

SECTION III

INSTRUMENTATION

(U) DBM-IV Milliken cameras running at 400 frames per second were used to record the propagation and area encompassed by the fireball.

(U) A Barnes model R8A2-5 radiometer was used to measure radiation from the fireball. The radiometer was calibrated in watts per square centimeter as represented by its output in microvolts. This output was recorded against time and converted to watts per steradian. Watts per steradian was then computed against time to give joules per steradian, radiation of less than 1% of peak being disregarded. Joules per steradian was finally converted to calories per steradian using the standard conversion factor of 1 calorie = 4.18 joules. Computation was then made of calories per square centimeter (cal/cm^2) at any distance (D) in centimeters by dividing calories per steradian by D^2.

(U) As a backup, special calorimeters were also employed to measure the radiation at various positions in and around the fireball and at measured distances from the munition. These calorimeters consisted of a 1.375 inch diameter copper disk 0.02 inches thick mounted on an aluminum block with a 0.75 inch thick teflon insulator between the aluminum and copper. Two copper-constantan thermocouples were soldered to the back side of the copper disk. The aluminum block, insulated from the heat, acted as a thermocouple reference junction. Sensitivity of the calorimeters was 0.05 calories per square centimeter per degree centrigrade.

SECTION IV

TEST PROCEDURES

(U) Forty-eight munitions were tested. The tests consisted of 11 single munition firings, 5 double munition firings, and 9 triple munition firings. All munitions were detonated in a vertical position with the fuze well on top (Figure 2).

(U) Figures 3 and 4 show two types of targets used during these tests. Each target was made up of various materials representing military targets, and located at known distances from the fireball munition. Indicator A (Figure 3) consisted of three types of cloth; white, black, and olive drab. Indicator B (Figure 4) consisted of one cotton strip, one neoprene rubber strip, one foam rubber strip, and three hardwood dowels of various diameters. Additional targets were newspaper and sand-filled bags made of black cloth. The amount of heat and radiation required to ignite newspaper is essentially the same as that at which human hair will burn and exposed skin will receive an instantaneous, second-degree burn. Therefore, the newspaper was included as a target material. Visual estimates of the burn damage to the materials were made after each test.

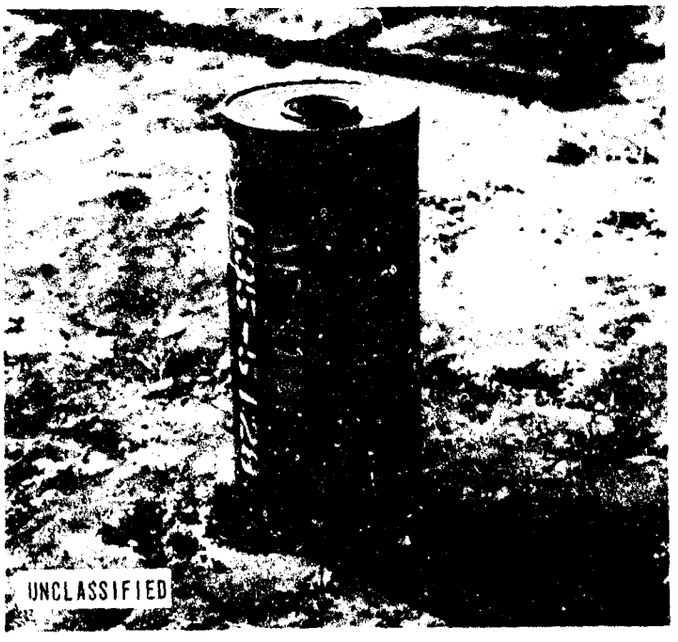

Figure 2. The Chemical Fireball Munition in Ground Level Firing Position.

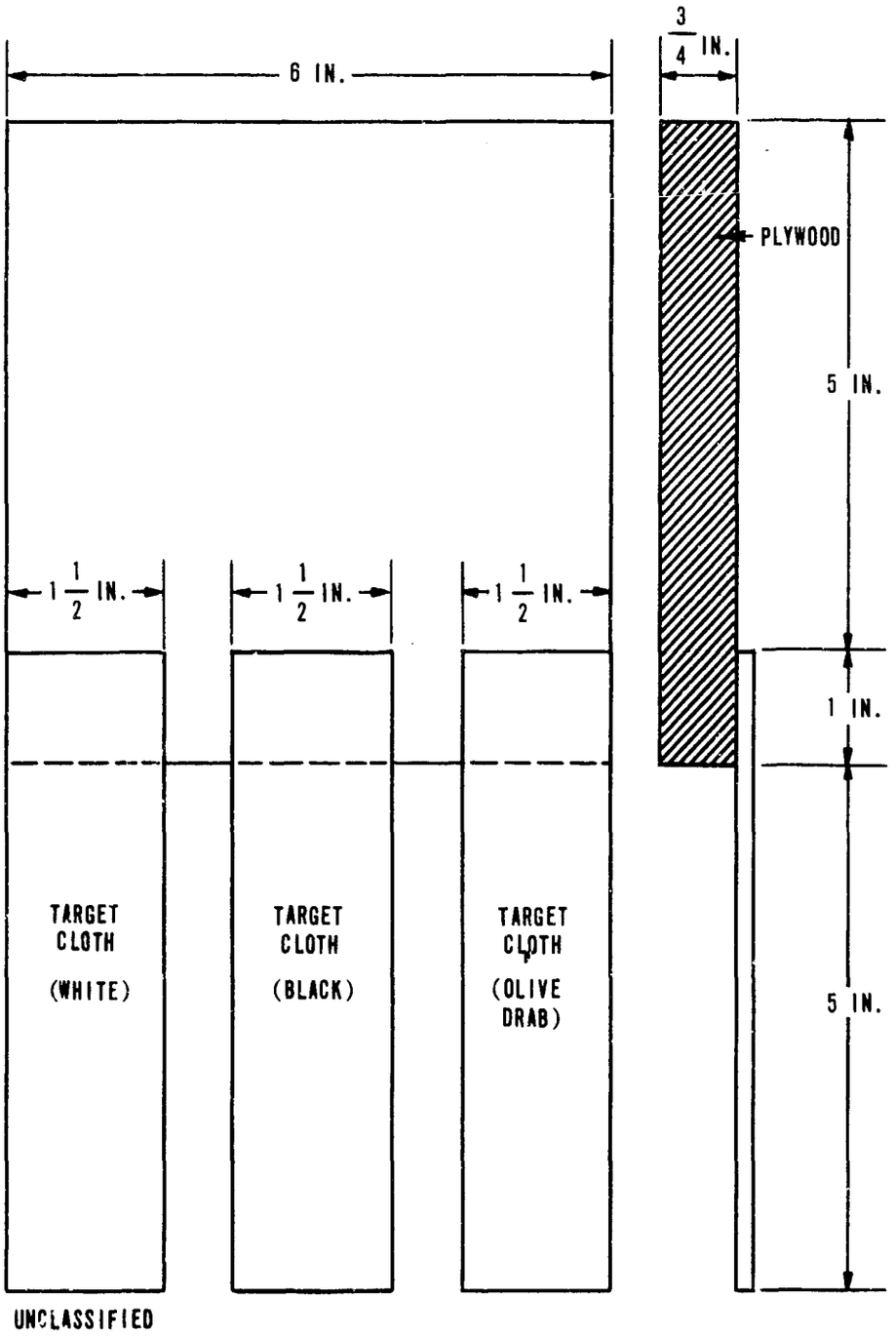

Figure 3. Indicator A.

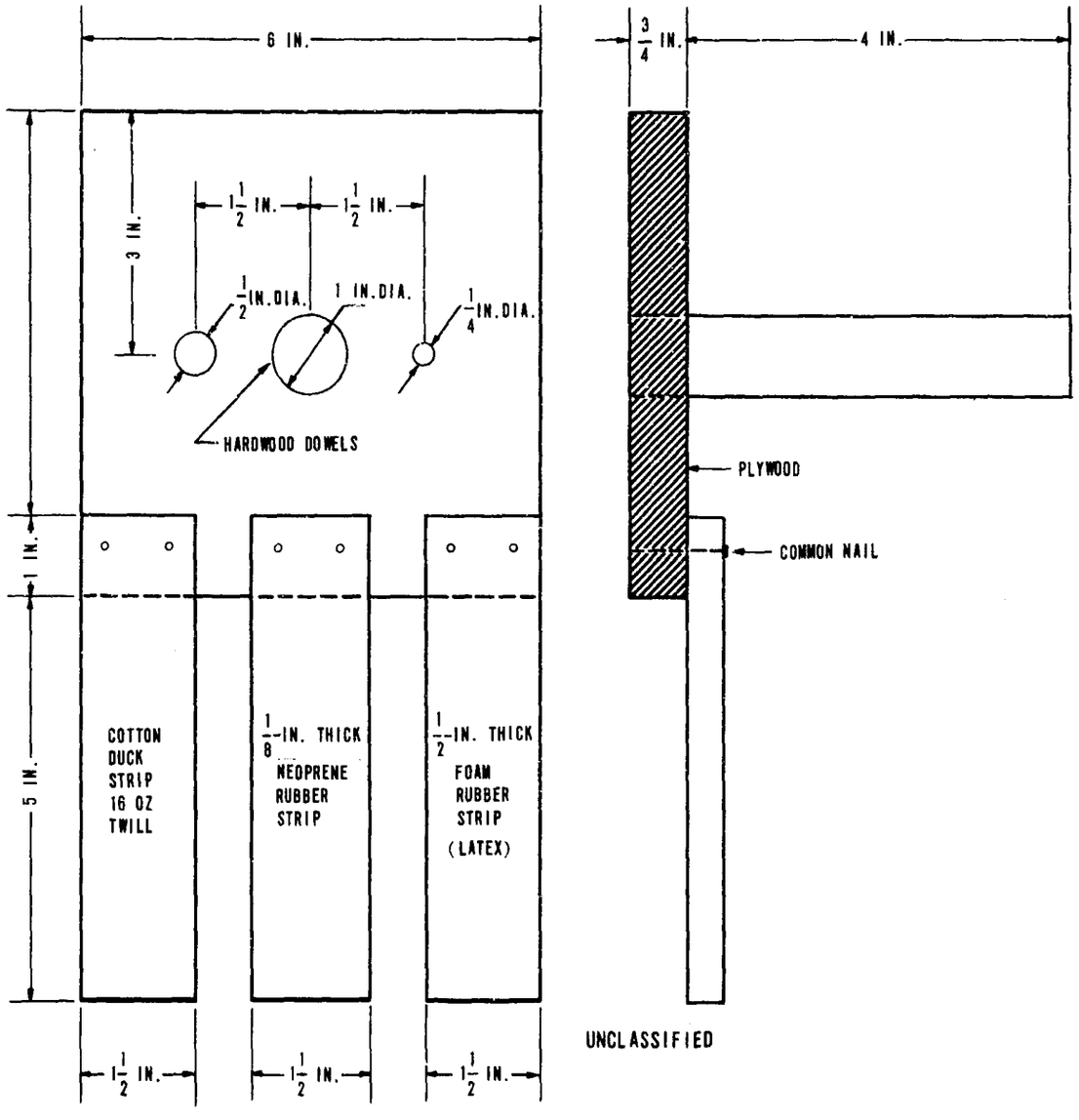

Figure 4. Indicator B.

(U) The indicators were mounted on datum poles approximately 20 inches apart (Figure 5). The newspaper was attached to metal coat hangers and fixed to the top and bottom of the datum poles. The sand-filled bags replaced the dowels in Tests 8 through 15.

(U) The basic test array consisted of 112 datum poles arranged as shown in Figure 6. There were 14 poles per row and 8 rows. The rows were lettered A through H for reference. The first 11 poles of each row were 1 foot apart, the last 3 were 2 feet apart. The first pole of each row was 5 feet from the ignition point of the munition.

(U) The basic array was used for Tests 1 through 4. For Tests 5 through 10, row B and the first two datum poles of the remaining rows were removed. All munitions for Tests 1 through 10 were detonated at ground level, with the exception of Test 7. The munition for this test was detonated 4 feet above ground level.

(U) Tests 11 through 15 consisted of firing two munitions simultaneously. Munition separation distance was 35 feet. The test setup for these firings consisted of the basic array plus a partial array, as shown in Figure 7. The partial array is designated array No. 2. All of these munitions were detonated at ground level.

(U) With the exception of Test 23, Tests 16 through 25 consisted of firing three munitions simultaneously. Figure 8 shows the target setup used for these tests.

(U) For Tests 20 and 21, all three munitions were placed 4 feet above the ground. For Tests 18, 22, and 24, two munitions were placed together in the basic array and one was placed in the No. 2 array. Three mannequins were added to the array for Test 23. One was located between rows F and G, 14 feet from the ignition point. Another was located 16 1/2 feet from the ignition point, between rows A and C. The remaining mannequin was placed 17 1/2 feet from the ignition point, between rows A and H. For Test 25, the target arrays were removed and 3 foxholes containing mannequins were used. These holes were 3 feet in diameter and spaced in line 35 feet apart. The munitions were placed at distances of 5 feet, 10 feet, and 15 feet from the foxholes.

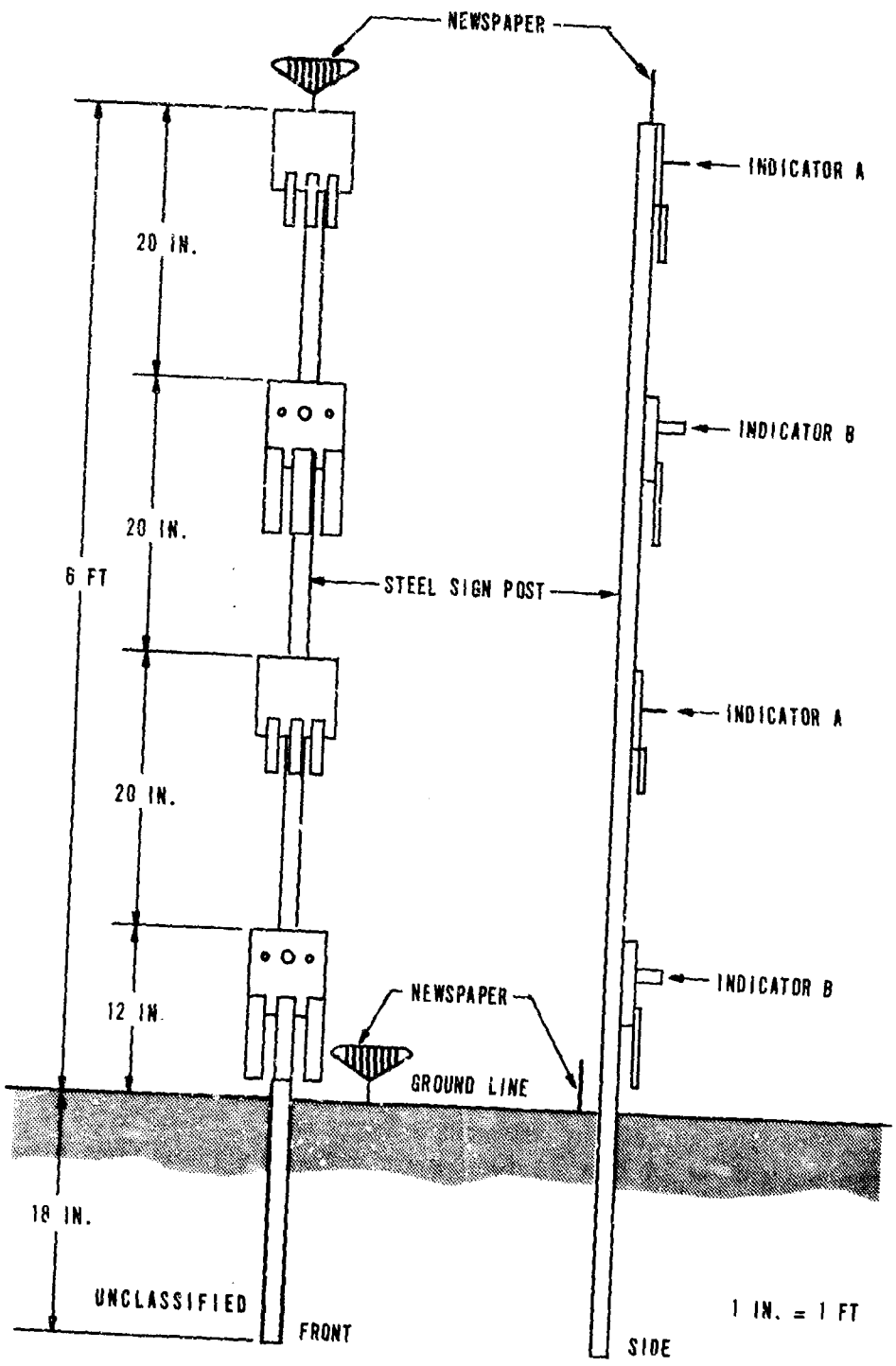

Figure 5. Standard Datum Poles Showing Location of Indicators.

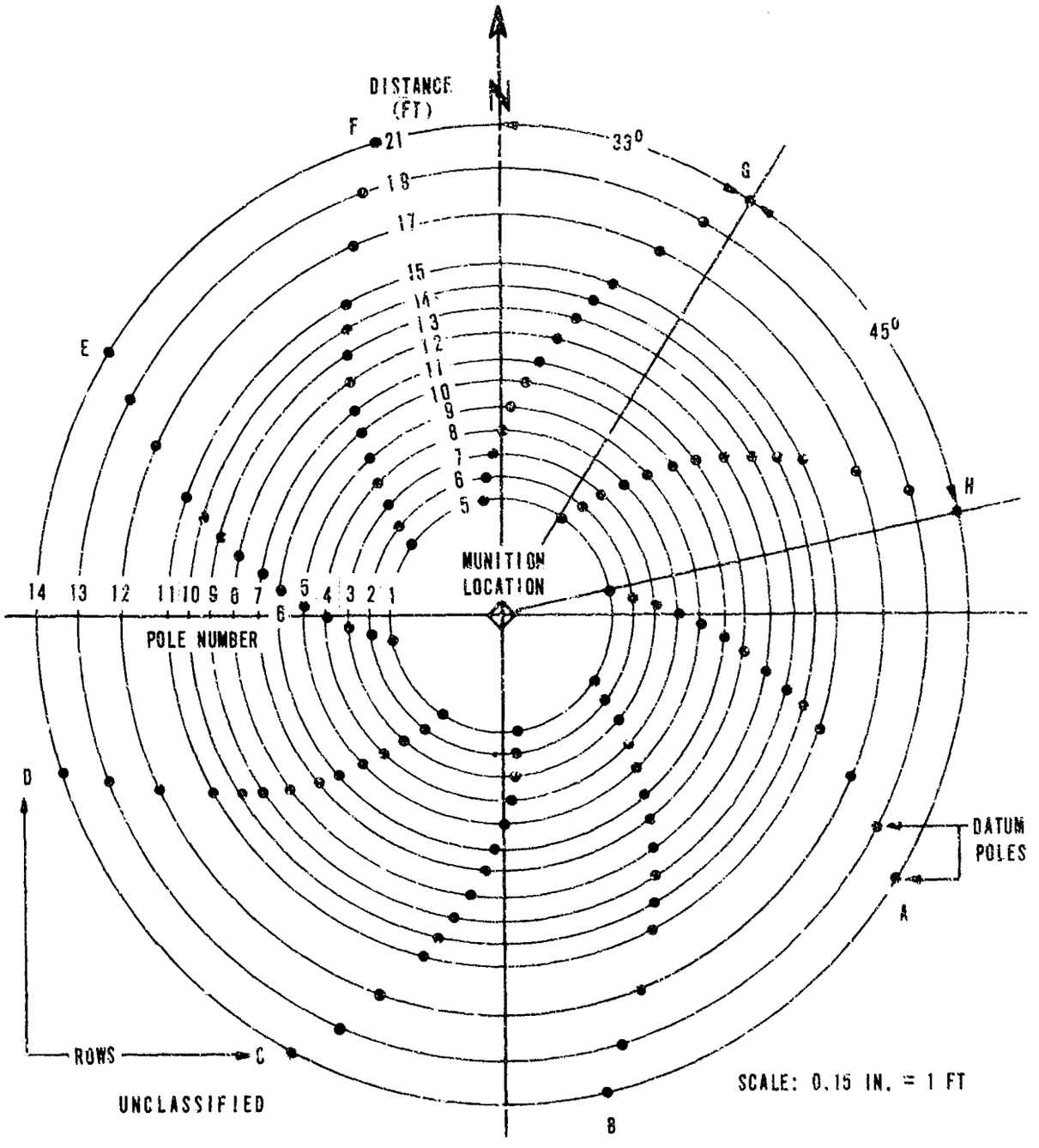

Figure 6. Target Array for Single Munition Firing.

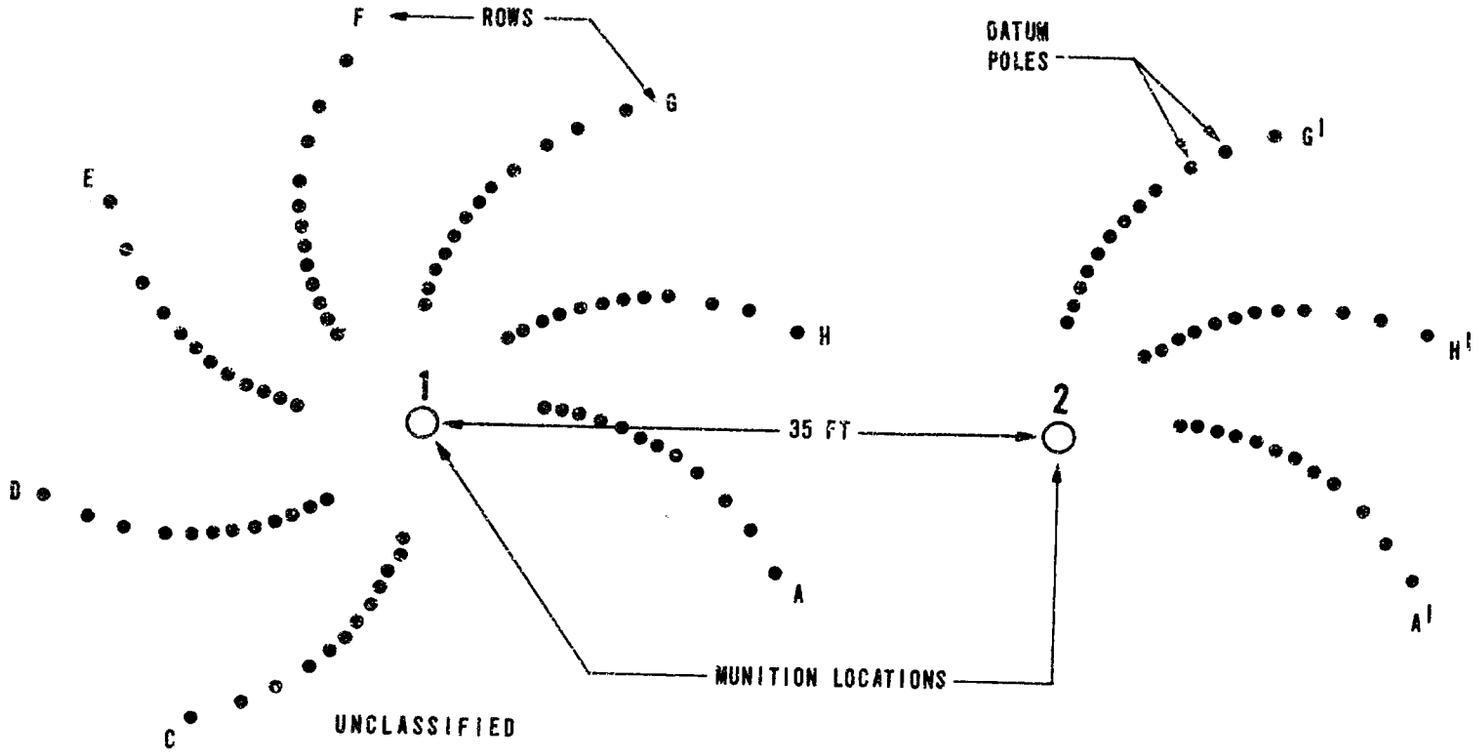

Figure 7. Target Array for Double Munition Firing.

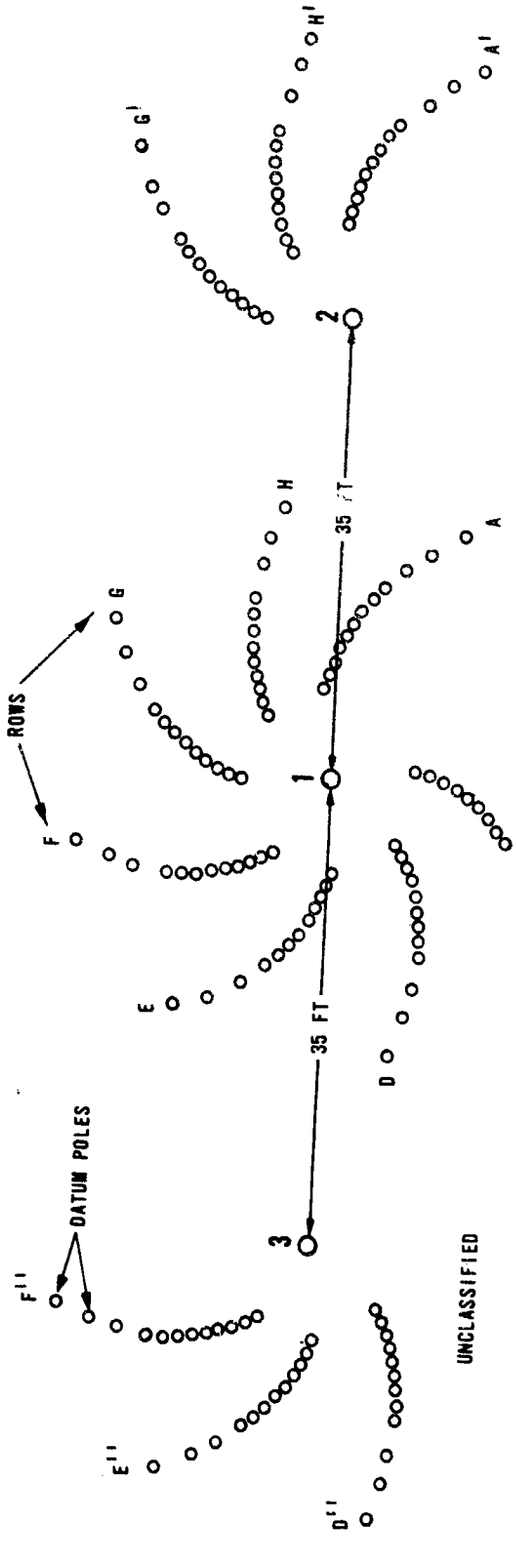

Figure 8. Target Array for Triple Munition Firing.

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SECTION V

TEST RESULTS AND DISCUSSION

(U) A summary of the ignition conditions is included in Tables I, II, and III. The munitions in Tests 7, 20, and 21 were placed 4 feet above ground level to provide a standard of comparison with the testing done by the manufacturer. The only munitions that did not ignite were those on Test 25. This was the result of faulty wiring from the control box to the munitions.

(C) The principal target damage by the munition occurred during the development of the fireball. Figures 9 through 13 show the vertical and horizontal propagation in feet of a fireball with respect to time for each firing condition. Figure 9 shows the propagation of a single munition, Figures 10 and 11 show the propagation of two munitions fired simultaneously and Figures 12 and 13 show the propagation of three munitions fired simultaneously. Although flame was still apparent through the 1000-millisecond contour lines, it was intermittent. The fireball, therefore, was considered to end after approximately 375 milliseconds.

BURN EFFECTS ON VARIOUS MATERIALS

(U) Table IV contains a summary of the burn effects of the fireball munition on various materials of military importance. These effects were obtained by visual estimates and are given for both ground level detonation and detonation 4 feet above ground level. The first column refers to the target material. The second column refers to the substance of which the target material is a representative sample. The first column for each type of detonation is the average burned distance from the detonation point of the munition. Burned distance as used refers to the complete consumption of the material by fire or radiation effects. The second column for each type of detonation refers to any other observed effect on the material by the munition, such as scorching, charring, or discoloring.

(C) For both the ground level and the 4-foot high detonations, the newspaper and the black cloth were burned at the greatest distances. At the ground level detonation, both of these materials had an average burn distance approximately 1 foot greater than the remaining materials. The burn effects were approximately the same for newspaper and the black cloth when detonated 4 feet off the ground. As shown in Table IV, the newspaper was scorched or otherwise affected at greater distances than any of the materials tested. When the munition was fired at ground level, the newspaper was affected over a foot farther than the black cloth (14.29 feet and 15.68 feet, respectively). However,

TABLE I. MISSION SUMMARY FOR SINGLE MUNITION DETONATIONS.

Test No.	Serial No. of Munitions	Munition Weight (grams)	Remarks	Test No.	Serial No. of Munitions	Munition Weight (grams)	Remarks
1	557	5,840	Ignited, no radiation data due to radiometer saturation.	8	558	5,820	Replaced dowels with sand bags on poles 3 through 8 of each row.
2	561	5,780		9	563	5,770	Removed neoprene rubber targets, sand bags moved to poles 4 through 9 of each row.
3	562	5,840					
4	552	5,810		10	569	5,830	
5	559	5,840	Removed row B and inner two poles of each remaining row.	23	576	5,781	Used mannequins covered with target materials.
6	551	5,762					
7	560	5,800	Munition placed 4 feet above ground level in vertical position with igniter on top.				

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TABLE II. MISSION SUMMARY FOR DOUBLE MUNITION DETONATIONS.

Test No.	Serial No. of Munitions	Munition Weight (grams)	Remarks*
11	550 554	5,790 5,780	---
12	553 556	5,800 5,770	---
13	573 574	5,890 5,800	---
14	567 571	5,860 5,810	0.10 second delay between detonations.
15	564 566	5,800 5,850	---

*All munitions fired at ground level.
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when the munition was fired 4 feet above ground level, the newspaper was affected 3 feet farther away than the black cloth. The neoprene rubber and the hardwood dowels offered the greatest resistance to the fireball. For Test 23, the newspaper on the mannequin placed at 14 feet from the ignition point was completely burned. The green cloth materials on the other two mannequins, placed 16 1/2 feet and 17 1/2 feet from the ignition point, were not affected. Figure 14 shows a typical row after the firing of a munition. The burn effects of the fireball munition on each type of material for each test are included in Appendix I. The difference between the maximum burn effects of the munition when detonated on the ground and 4 feet above the ground was shown to be statistically significant using the "t-test".

EFFECTIVE BURN AREA

(C) The effective burn area is the area encompassing the maximum distance of burn damage (second-degree burns). This area includes both radiation and fireball burn damage. Appendix II contains the effective burn area plots for each test. This area is obtained by plotting the actual burn damage and making a graphical analysis of this plot using a planimeter. The wind direction and velocity are stated on each plot. When the wind velocity was above 5 knots a noticeable shift in the burn damage was apparent. The burn area plots show how

TABLE III. MISSION SUMMARY FOR TRIPLE MUNITION DETONATIONS.

Test No.	Serial No. of Munitions	Munition Weight (grams)	Remarks	Test No.	Serial No. of Munitions	Munition Weight (grams)	Remarks
16	596 597 598	5,778 5,768 5,800	---	21	582 584 586	5,794 5,809 5,790	All three munitions were placed 4 feet above the ground, one in each test array.
17	595 599 600	5,767 5,797 5,809	Munition in center array was fired first and then two outer munitions fired simultaneously.	22	572 578 579	5,751 5,803 5,785	Two munitions placed in center array and one in No. 2 array.
18	588 590 592	5,780 5,793 5,829	Placed two munitions together in center array and one in No. 2 array.	24	577 580 602	5,797 5,790 5,806	Placed mannequins around point of detonation. Two munitions placed in center array and one in No. 2 array.
19	591 593 594	5,779 5,804 5,800	One munition in each test array.	25	603 606 607	5,761 5,762 5,808	All targets removed and three fox holes dug with munitions placed just outside of them. Two munitions did not fire due to faulty wiring.
20	581 583 587	5,798 5,793 5,822	All three munitions were placed 4 feet above the ground, one in each test array.				

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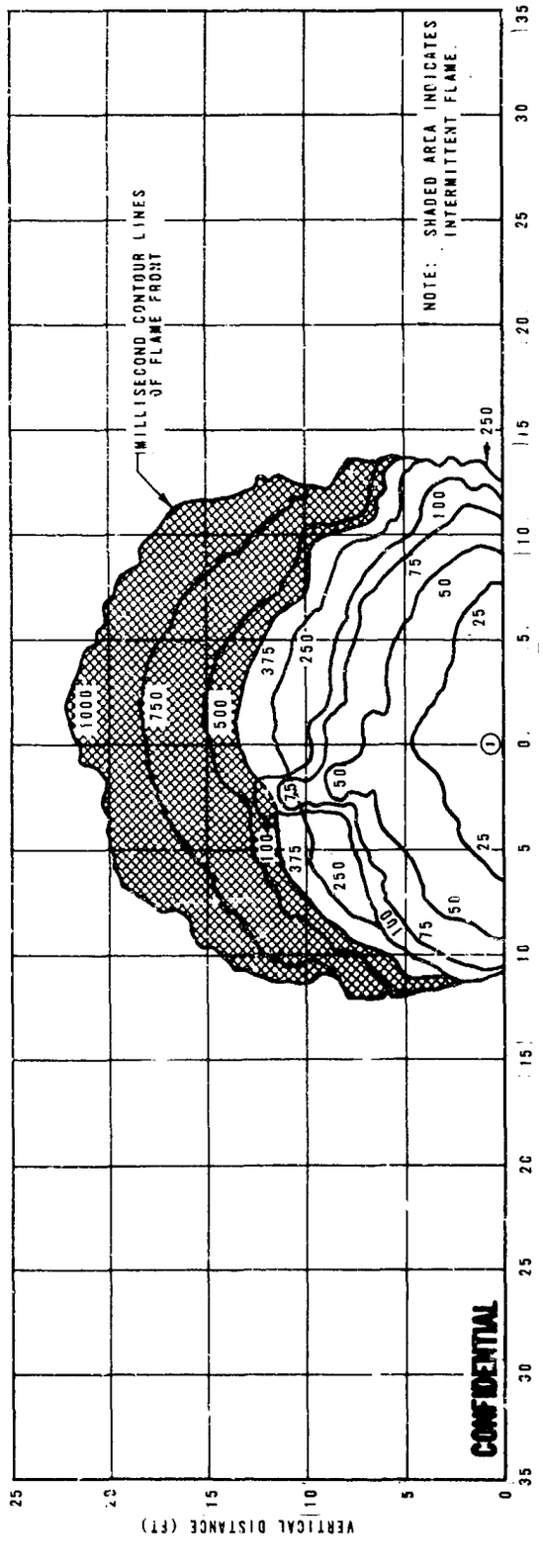

Figure 9. Fireball Propagation of a Single Munition.

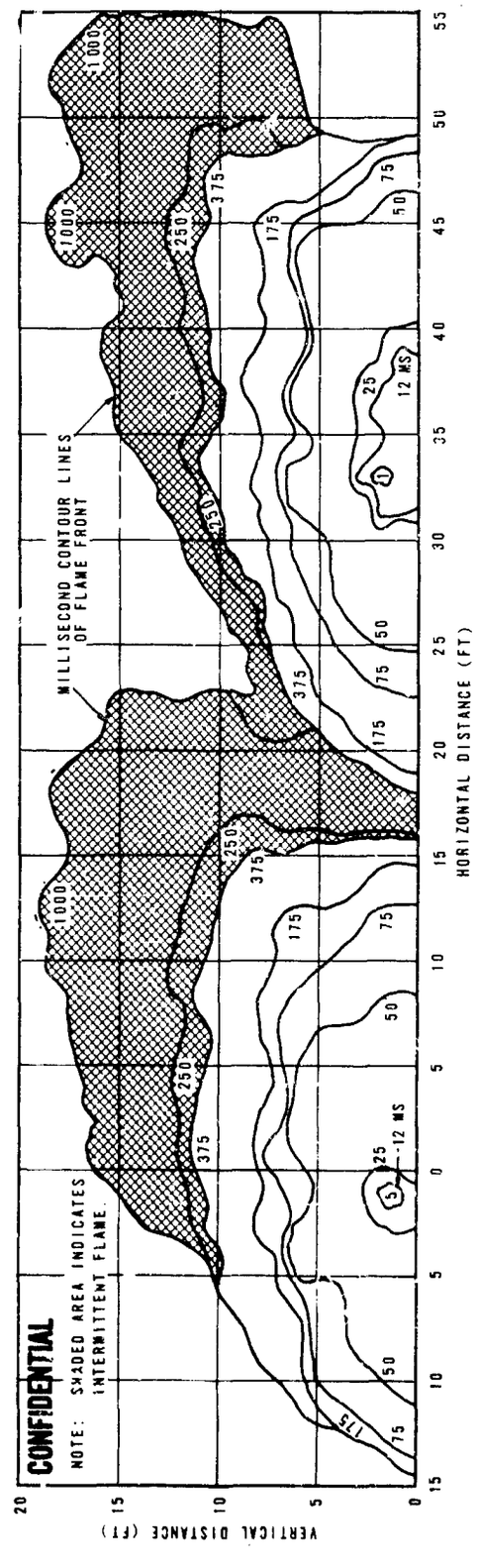

Figure 10. Fireball Propagation of Two Munitions Fired Simultaneously, View 1 (Frontal View).

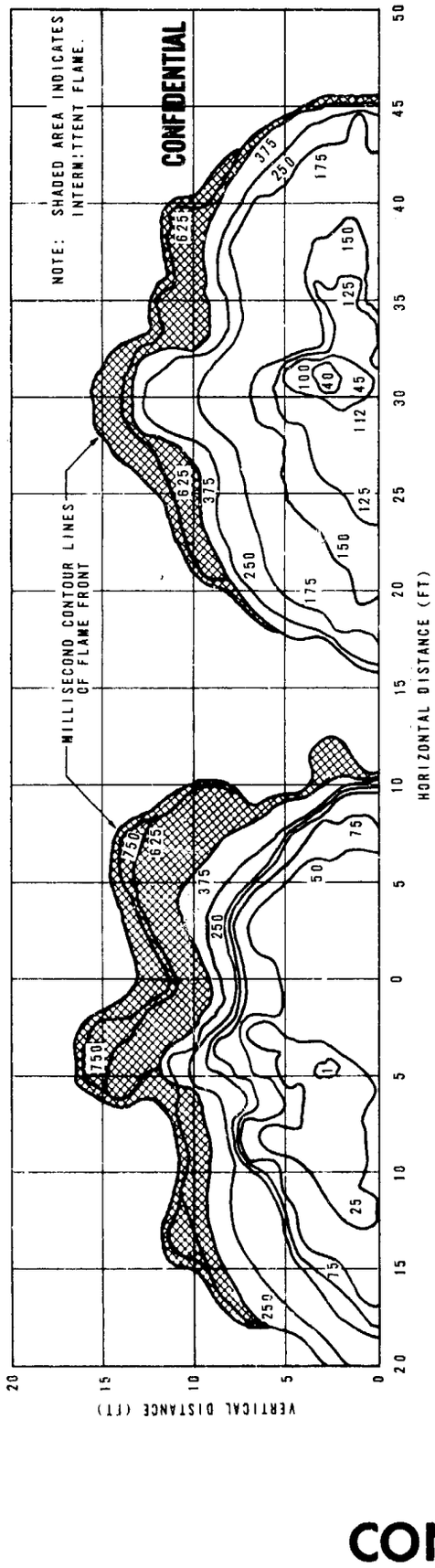

Figure 11. Fireball Propagation of Two Munitions Fired Simultaneously, View 2 (Side View).

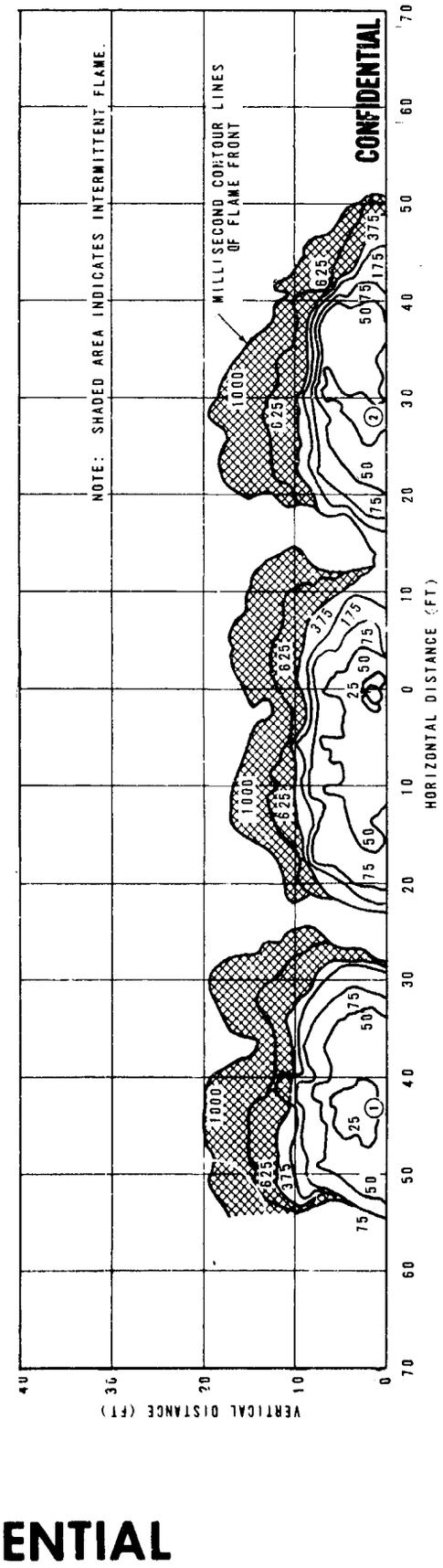

Figure 12. Fireball Propagation of Three Munitions Fired Simultaneously, View 1 (Frontal View).

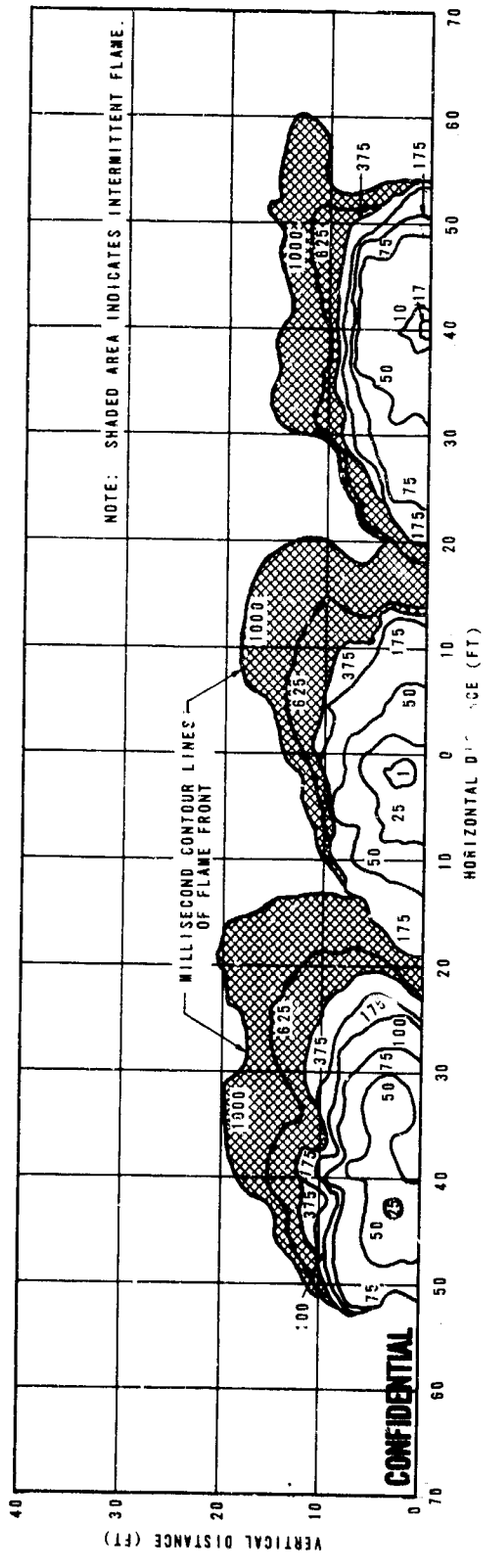

Figure 13. Fireball Propagation of Three Munitions Fired Simultaneously, View 2 (Side View).

TABLE IV. SUMMARY OF BURN EFFECTS ON VARIOUS MATERIALS OF MILITARY IMPORTANCE.

Target Material Used	Material Represented by Targets	Ground Level Detonation Average Distance (ft)		4-Foot High Detonation Average Distance (ft)	
		Burned[1]	Affected[2]	Burned[1]	Affected[2]
Green cloth	Fatigue material	12.14	12.91	12.36	13.30
White cloth	Target cloth	12.11	13.28	11.09	13.67
Black cloth	Viet Cong uniforms	14.25	14.29	14.91	15.09
Cotton twill	Heavy material, canvas	13.04	13.18	12.08	11.96
Neoprene	Tires, shoe soles	---	11.82	---	12.71
Foam rubber	Light rubber	13.28	13.73	12.08	12.92
Hardwood dowels	Wooden structures	---	11.92	---	12.00
Black cloth sand bags	Viet Cong uniforms	---	12.86	---	---
Newspaper	Human hair, skin	14.34	15.68	15.31	18.08

[1] Refers to complete destruction of the material by fire or radiation.

[2] Refers to any effect, other than complete destruction, such as; scorching, charring, or discoloring.

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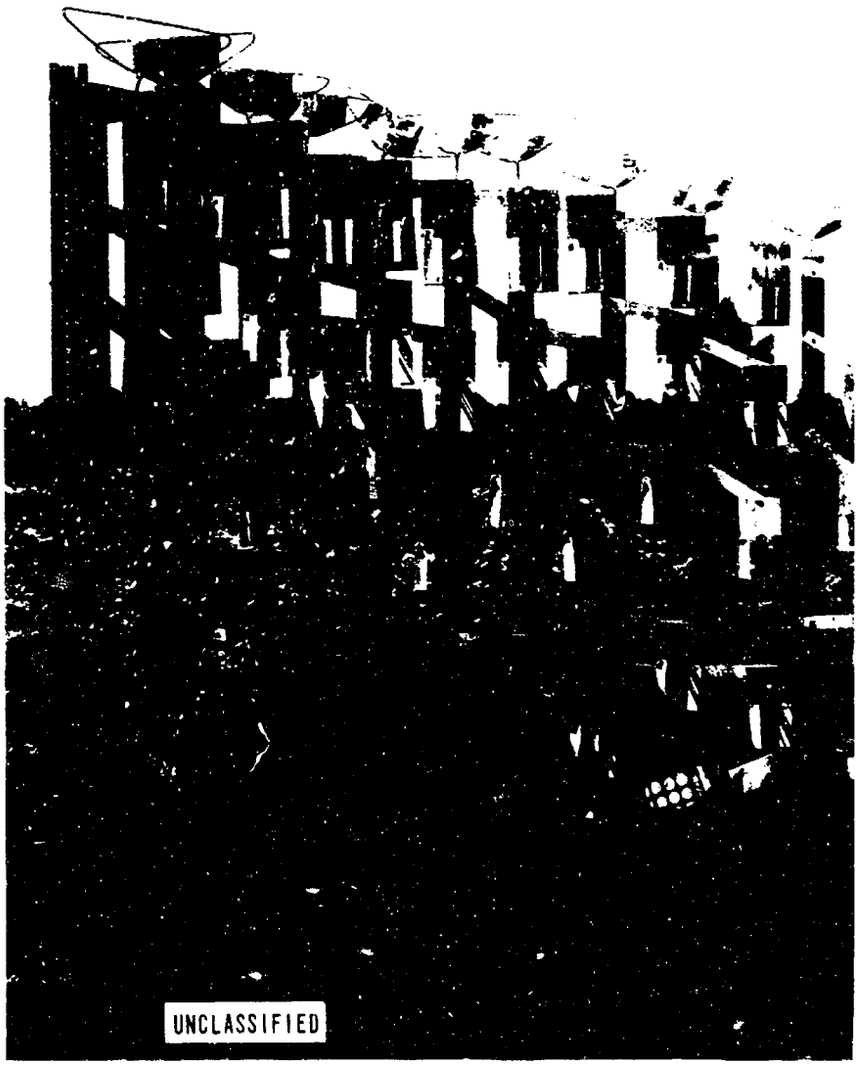

Figure 14. A Typical Row of Datum Poles Showing Damage After Firing of the Chemical Fireball Munition.

TABLE V. EFFECTIVE BURN AREAS OF SINGLE MUNITION DETONATIONS.

Test No.	Area (ft^2)
1	520
2	385
3	580
4	535
5	620
6	645
7*	685
8	510
9	660
10	618
23	570
	Average 564.3

* Placed 4 feet above ground (not included in average).

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the shape of the burn area was affected by the wind. Figure 10 shows how the flame was affected by a 10-knot wind during the 1-second duration of the fireball.

(C) A summary of the effective burn areas of the single munition firings is shown in Table V. The areas for the ground level firings ranged from 385 square feet to 660 square feet. Table VI lists the effective areas of the double munition firings. Table VII lists the effective burn area for the munition firings detonated on the ground and 4 feet off the ground. The average effective burn area for 32 munitions fired at ground level was 557.9 square feet. The

TABLE VI. EFFECTIVE BURN AREAS OF DOUBLE MUNITION DETONATIONS*.

Test No.	Area of Munition No. 1 (ft^2)	Area of Munition No. 2 (ft^2)
11	525	555
12	580	595
13	630	610
14	555	555
15	655	460
	Average 589	555

* Munition placed 35 feet apart and detonated on the ground.

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TABLE VII. EFFECTIVE BURN AREAS OF TRIPLE MUNITION DETONATIONS WITH ONE MUNITION IN EACH ARRAY.

Test No.	Ground Level Detonation Area (ft^2)		
	Munition No. 1	Munition No. 2	Munition No. 3
16	575	635	490
17	490	455	475
19	705	680	515
Test No.	**4-Foot High Detonation Area (ft^2)**		
	Munition No. 1	**Munition No. 2**	**Munition No. 3**
20	825	710	850
21	550	665	610

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average effective burn area for the seven munitions detonated 4 ft above ground was 699 square feet. This is an increase of 25.3 percent. In all cases the areas for the 4-foot high detonations were greater than the ground level detonations.

(C) Individual munitions for the double and triple firings were placed 35 feet apart and fired simultaneously to determine if the fireballs of the munitions would overlap. This distance was chosen on a predicted burn radius. In each configuration there were cases of overlap and non-overlap. Even in the case of the triple firings detonated 4 feet off the ground the overlap was not consistent. (See Tests 20 and 21, Appendix II.) For some firings, the overlap was as much as 7.5 feet. In other firings, the burn areas were separated by as much as 8.5 feet. Therefore, the maximum distance between munitions for an effective interaction of burn areas is considered to be approximately 25.5 feet, allowing for a 1-foot overlap of the burn areas.

(C) The effective burn areas of a simultaneous firing of two munitions, placed together, are shown in Table VIII. These munitions were part of three triple munition firings made with two in the center array and one in the No. 2 array. All of these firings were made at ground level. The largest burn area was 1050 square feet for Test 22. This represents an increase in effective burn area of 88.2 percent over the average burn area for the 32 separate munitions fired at ground level. The smallest area was 950 square feet for Test 18. This is an increase in burn area of 70.3 percent over the same average for separate munitions. The average burn area for the double munition firings was 1006 square feet. This was an increase of 80.3 percent over the average for the 32 separate munition burn areas.

TABLE VIII. EFFECTIVE BURN AREAS OF TRIPLE MUNITION DETONATIONS WITH TWO IN CENTER ARRAY AND ONE IN NO. 2 ARRAY.

Test No.	Area of Double Munition (ft^2)	Area of No. 2 Munition (ft^2)
18	950	540
22	1,050	440
24	1,020	490
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RADIATION

(C) Table IX shows the radiation emitted by the fireball for Tests 1 through 10, and Tests 23 and 25. The radiation is given in cal/cm^2 at distances of 5 feet, 10 feet, and 20 feet from the ignition point of the fireball. The radiometer data were extrapolated by means of the inverse square law to obtain the radius in feet from the ignition point at which a radiation level was 3 cal/cm^2. This is the level of flash radiation that will burn the black cloth and the newspaper[1]. In order to estimate the actual amount of energy transmitted by the fireball at the given distances, allowances were made for atmospheric attenuation. The numbers in Table IX have been corrected for this attenuation. For 3 cal/cm^2, the average radius was 13.18 feet for ground level detonation. This is approximately 1 foot less than the average burn distance noted for the black cloth and the newspaper given in Table II. The radius for the 4-foot above ground detonation was 16 feet (Test 7). The maximum burn damage for this test was 15 feet for the black cloth and the newspaper. This calculated radiation compared favorably with actual burn distance.

(C) The radiation data obtained from the calorimeters bore such little correlation with the actual data obtained from visual scoring that they were discarded as inconclusive.

SHOCK WAVES

(C) The results obtained from the first few tests revealed no significant overpressures generated by the detonation of the fireball munitions. This part of the testing was therefore terminated.

---

[1] Reference 3.

TABLE IX. THERMAL RADIATION DATA FOR THE SINGLE MUNITION DETONATIONS.

Test No.	Radiation (cal/cm^2)*			Radius for 3 cal/cm^2 (ft)
	5 ft	10 ft	20 ft	
1**	---	---	---	---
2	21.58	5.40	1.30	15.27
3	16.38	4.08	1.04	13.26
4	15.60	3.90	.97	12.96
5	18.20	4.55	1.17	14.04
6	17.29	4.29	1.04	13.65
7†	23.53	5.85	1.43	15.99
8	12.48	3.12	.78	11.70
9	13.13	3.25	.78	11.96
10	8.97	2.21	.52	9.88
23	18.72	4.68	1.17	14.32
25††	20.02	5.07	1.30	14.71
Average	16.23	4.06	1.01	13.18

* Radiation calculated over 1-second time period.
** Test 1 had no data as a result of radiometer saturation.
† The munition was placed 4 feet above ground level; not included in average.
†† Two munitions did not function on this test; it was therefore considered as a single munition test.

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SECTION VI

SUMMARY OF RESULTS

1. (C) The chemical fireball munition caused burning effects on targets simulating personnel and equipment at an average distance of 15.68 feet from the point of detonation, when detonated at ground level and 18.08 feet when detonated 4 feet above ground level.

2. (C) The average effective burn area for 32 separate chemical fireball munitions detonated at ground level was 557.9 square feet. The average effective burn area for 7 separate chemical fireball munitions detonated 4 feet above ground level was 699 square feet.

3. (C) Wind velocity had a marked effect on the area burned by the munition. There was a noticeable shift in the location of the area affected by burn damage when the wind velocity exceeded 5 knots.

4. (C) The burn areas of two chemical fireball munitions placed side by side and fired simultaneously were not additive.

5. (C) The maximum distance between munitions detonated simultaneously for and effective interaction of burn areas was approximately 25.5 feet.

6. (C) There was no significant shock wave produced by the chemical fireball munition.

REFERENCES

ATL-TR-65-65, Chemical Fireball Munition Concept, Phase II, Confidential Gp-4 report, dated October 1965.

LWL-CR05C66, Characterization of a Chemical Fireball, Confidential Gp-4 report, dated December 1960.

United States Atomic Energy Commission, The Effects of Nuclear Weapons, Unclassified document, dated April 1962.

APPENDIX I

BURN EFFECTS ON VARIOUS MATERIALS

(U) The burn effects of the chemical fireball munition on various materials of military importance for each of 24 tests are shown in Tables I-1 through I-24. The columns headed B refer to the distance in feet from the point of detonation at which the material is completely burned. The columns headed A refer to the distances in feet from the point of detonation at which there is any other observed effect on the material, such as scorching, charring, or discoloring. The wooden dowels were never completely burned.

Table I - 1. Fireball Effects on Various Materials, Test I

Row	Cloth								Neoprene		Foam			News-Paper		Wooden Dowels
	Green		White		Black		Cotton									
	B	A	B	A	B	A	B	A	B	A	B	A		B	A	
A	10	10	10	10	10	10	10	10	--	10	10	10		10	15	10
B	8	8	9	9	9	9	9	9	--	10	10	10		12	12	10
C	10	10	13	13	13	13	10	10	--	8	10	10		11	15	12
D	15	15	15	15	15	15	14	14	--	15	15	15		15	17	15
E	11	11	11	11	11	11	10	10	--	8	9	9		10	15	9
F	12	12	11	11	13	13	9	9	--	9	10	10		10	13	10
G	17	17	17	17	17	17	15	15	--	15	17	17		17	19	17
H	15	15	15	15	15	15	15	15	--	15	15	15		17	17	15

Table I - 2. Fireball Effects on Various Materials, Test I

Row	Cloth								Neoprene		Foam			News-Paper		Wooden Dowels
	Green		White		Black		Cotton									
	B	A	B	A	B	A	B	A	B	A	B	A		B	A	
A	10	10	10	10	10	10	10	10	--	10	10	10		10	12	10
B	9	9	11	11	9	11	10	11	--	11	11	11		11	11	11
C	9	11	11	11	11	11	10	11	--	11	13	13		13	13	10
D	8	9	10	10	9	9	9	9	--	10	9	10		9	11	10
E	8	8	8	8	8	8	6	7	--	5	7	8		9	11	5
F	11	11	14	14	11	11	10	12	--	11	13	14		13	15	10
G	17	17	17	17	15	17	15	17	--	15	17	17		19	19	15
H	12	14	15	15	14	15	12	15	--	15	15	15		14	15	12

Table I - 3. Fireball Effects on Various Materials, Test 3

	Cloth														
	Green		White		Black		Cotton		Neoprene		Foam		News-paper		Wooden Dowels
Row	B	A	B	A	B	A	B	A	B	A	B	A	B	A	
A	11	11	9	11	11	11	10	13	UNK	13	13	13	13	13	13
B	7	9	10	15	15	15	10	15	UNK	15	14	15	15	15	10
C	8	10	9	11	12	12	8	11	UNK	11	11	14	12	15	11
D	11	12	11	13	13	13	12	12	UNK	11	13	14	14	15	11
E	13	13	13	14	15	'	10	13	UNK	11	13	15	15	17	11
F	14	17	17	17	17	17	14	14	UNK	13	15	17	17	19	14
G	11	13	13	14	14	14	12	13	UNK	13	13	14	13	14	13
H	5	9	9	11	11	11	11	13	UNK	13	13	13	12	12	10

Table I - 4. Fireball Effects on Various Materials, Test 4

	Cloth														
	Green		White		Black		Cotton		Neoprene		Foam		News-paper		Wooden Dowels
Row	B	A	B	A	B	A	B	A	B	A	B	A	B	A	
A	10	11	10	11	11	11	10	10	UNK	10	10	10	10	12	10
B	8	9	11	11	11	11	10	10	UNK	10	10	10	10	14	10
C	13	14	15	15	15	15	15	15	UNK	15	14	14	15	17	15
D	14	14	15	15	15	15	15	15	UNK	15	15	15	15	17	15
E	11	12	13	13	14	14	14	14	UNK	13	13	13	14	15	13
F	10	10	10	10	11	11	11	11	UNK	9	12	12	13	13	9
G	11	11	13	13	13	13	11	11	UNK	10	13	13	14	15	12
H	17	17	17	17	17	17	17	17	UNK	17	17	17	17	17	17

Table I - 5. Fireball Effects on Various Materials, Test 5

Row	Cloth								Neoprene		Foam		Newspaper		Wooden Dowels
	Green		White		Black		Cotton								
	B	A	B	A	B	A	B	A	B	A	B	A	B	A	
A	14	14	14	15	17	17	17	17	UNK	12	17	17	19	21	14
C	15	15	15	15	15	15	15	15	UNK	15	15	15	15	15	15
D	11	11	13	13	13	13	15	15	UNK	13	13	13	15	15	13
E	8	8	9	9	11	11	10	10	UNK	9	9	9	UNK	10	9
F	7	7	7	9	9	9	9	9	UNK	9	9	9	9	9	9
G	9	12	11	12	14	14	13	13	UNK	13	13	13	13	14	11
H	17	17	15	17	19	19	17	17	UNK	15	19	19	19	21	15

Table I - 6. Fireball Effects on Various Materials, Test 6

Row	Cloth								Neoprene		Foam		Newspaper		Wooden Dowels
	Green		White		Black		Cotton								
	B	A	B	A	B	A	B	A	B	A	B	A	B	A	
A	12	13	12	14	14	14	13	13	UNK	13	13	17	14	15	13
C	11	11	12	13	15	15	15	15	UNK	14	14	15	15	15	14
D	8	9	9	10	11	11	9	9	UNK	9	9	11	10	13	9
E	11	11	9	11	14	15	14	14	UNK	14	14	15	14	17	14
F	11	13	14	14	14	14	13	13	UNK	13	13	14	13	17	12
G	12	13	11	13	15	15	14	14	UNK	9	14	15	14	17	14
H	11	12	12	12	13	13	14	14	UNK	13	14	14	14	15	11

Table I - 7. Fireball Effects on Various Materials, Test 7

	Cloth														
	Green		White		Black		Cotton		Neoprene		Foam		News-paper		
Row	B	A	B	A	B	A	B	A	B	A	B	A	B	A	Dowels
A	13	14	13	14	14	15	14	14	UNK	14	14	14	15	17	14
C	9	10	8	10	13	13	10	10	UNK	10	10	10	11	15	10
D	12	13	9	13	15	15	11	11	UNK	11	11	12	12	17	12
E	13	14	12	14	15	15	14	14	UNK	13	14	14	15	17	13
F	13	14	12	15	15	15	15	15	UNK	15	15	15	15	21	10
G	15	15	14	17	17	17	19	19	UNK	15	15	19	19	19	14
H	10	13	13	14	15	15	13	13	UNK	12	11	13	17	19	11

Table I - 8. Fireball Effects on Various Materials, Test 8

	Cloth														
	Green		White		Black		Cotton		Neoprene		Foam		News-paper		Sand
Row	B	A	B	A	B	A	B	A	B	A	B	A	B	A	Bag
A	15	17	13	17	17	17	15	15	UNK	12	15	15	17	19	12
C	11	13	11	13	15	15	12	12	UNK	12	9	12	14	15	12
D	15	15	15	15	15	15	15	15	UNK	14	15	15	15	15	12
E	12	12	9	13	15	15	13	13	UNK	13	13	13	14	14	12
F	11	11	9	11	13	13	12	12	UNK	12	12	12	12	12	11
G	UNK	UNK	UNK	7	9	9	9	9	UNK	10	10	10	10	10	7
H	7	10	UNK	10	12	12	7	10	UNK	10	10	10	10	11	11

Table I - 9. Fireball Effects on Various Materials, Test 9

	Cloth														
	Green		White		Black		Cotton		Neoprene		Foam		News-paper		Sand
Row	B	A	B	A	B	A	B	A	B	A	B	A	B	A	Bag
A	11	11	12	12	15	15	15	15	UNK	11	15	15	15	17	13
C	19	21	21	21	21	21	21	21	UNK	12	21	21	21	21	13
D	8	10	9	11	11	11	11	11	UNK	10	10	10	11	12	9
E	UNK	7	7	9	9	9	9	9	UNK	9	9	9	12	12	UNK
F	12	12	9	9	13	13	14	14	UNK	13	13	13	14	14	8
G	14	17	17	17	17	17	15	17	UNK	15	15	15	17	17	13
H	13	13	13	13	15	15	13	13	UNK	13	13	14	15	15	13

Table I - 10. Fireball Effects on Various Materials, Test 10.

	Cloth														
	Green		White		Black		Cotton		Neoprene		Foam		News-paper		Sand
Row	B	A	B	A	B	A	B	A	B	A	B	A	B	A	Bag
A	9	9	9	11	11	11	12	12	UNK	12	12	12	12	12	9
C	UNK	7	UNK	UNK	7	7	9	9	UNK	8	8	9	9	10	UNK
D	11	11	9	11	15	15	12	12	UNK	11	14	14	13	15	13
E	21	21	17	21	21	21	21	21	UNK	21	21	21	21	21	13
F	17	19	17	21	21	21	19	19	UNK	19	17	19	21	21	13
G	13	13	12	13	15	15	15	15	UNK	13	13	14	14	14	13
H	11	11	11	13	13	13	13	13	UNK	13	13	13	9	9	12

Table I - 11. Fireball Effects on Various Materials, Test 11

	Cloth														
	Green		White		Black		Cotton		Neoprene		Foam		Newspaper		Sand
Row	B	A	B	A	B	A	B	A	B	A	B	A	B	A	Bag
A	13	15	12	15	17	17	13	14	UNK	13	13	17	15	17	15
C	11	11	9	11	11	11	12	12	UNK	11	11	11	12	12	UNK
D	7	8	7	9	10	10	10	10	UNK	11	11	11	10	11	UNK
E	11	12	11	11	13	13	14	14	UNK	13	14	14	13	14	13
F	10	11	9	11	12	12	12	12	UNK	10	10	11	10	11	UNK
G	8	12	9	11	13	13	10	11	UNK	10	11	11	12	13	UNK
H	17	19	15	19	21	21	21	21	UNK	17	15	21	21	21	17
A'	9	9	9	12	13	13	11	11	UNK	9	10	12	11	12	14
G'	11	15	11	13	15	15	13	13	UNK	9	13	13	13	15	15
H'	11	12	10	13	13	13	13	13	UNK	11	13	13	13	14	13

Table I - 12. Fireball Effects on Various Materiald, Test 12.

	Cloth														
	Green		White		Black		Cotton		Neoprene		Foam		Newspaper		Sand
Row	B	A	B	A	B	A	B	A	B	A	B	A	B	A	Bag
A	UNK	9	8	10	11	11	10	10	UNK	10	10	11	11	14	UNK
C	12	12	11	11	12	12	12	12	UNK	12	12	15	11	13	12
D	12	14	9	14	15	17	13	13	UNK	10	13	21	11	17	14
E	13	13	12	14	15	15	13	13	UNK	11	12	13	15	17	12
F	UNK	11	13	13	11	12	12	12	UNK	11	10	12	14	15	12
G	17	17	17	19	19	19	19	19	UNK	12	17	17	21	21	UNK
H	10	10	10	10	10	11	10	10	UNK	9	9	9	12	15	12
A'	8	14	12	14	15	15	17	17	UNK	14	15	15	17	17	14
G'	11	14	12	14	15	15	15	15	UNK	13	15	15	15	15	13
H'	7	8	7	9	9	9	13	13	UNK	8	8	9	10	11	UNK

Table I - 13. Fireball Effects on Various Materials, Test 13

	Cloth														
	Green		White		Black		Cotton		Neoprene		Foam		Newspaper		Sand
Row	B	A	B	A	B	A	B	A	B	A	B	A	B	A	Bag
A	11	13	11	13	15	17	17	17	UNK	17	17	17	17	17	UNK
C	UNK	UNK	UNK	UNK	8	8	7	7	UNK	7	7	8	UNK	UNK	UNK
D	11	11	9	11	14	14	15	15	UNK	10	15	15	10	10	14
E	11	11	10	11	12	12	12	12	UNK	10	11	11	11	12	12
F	14	17	12	15	17	17	17	17	UNK	14	19	19	17	19	15
G	11	13	12	13	14	14	14	14	UNK	14	14	14	14	14	13
H	11	13	11	13	15	15	14	14	UNK	14	13	15	14	17	14
A'	8	11	9	11	11	11	13	13	UNK	13	13	13	13	13	UNK
G'	13	13	11	13	17	17	13	13	UNK	11	12	14	15	15	15
H'	9	14	9	13	15	15	14	14	UNK	10	13	13	14	14	15

Table I - 14. Fireball Effects on Various Materials, Test 14

	Cloth														
	Green		White		Black		Cotton		Neoprene		Foam		Newspaper		Sand
Row	B	A	B	A	B	A	B	A	B	A	B	A	B	A	Bag
A	8	8	10	10	10	10	UNK	8	UNK	8	UNK	8	10	13	UNK
C	9	9	9	9	9	9	UNK	8	UNK	8	UNK	8	10	10	UNK
D	UNK	8	7	7	10	10	UNK	8	UNK	7	UNK	7	10	11	UNK
E	15	15	15	15	15	15	UNK	12	UNK	10	UNK	10	17	17	14
F	11	12	11	12	13	13	7	12	UNK	7	UNK	7	13	15	13
G	11	13	11	13	15	15	UNK	9	UNK	UNK	UNK	UNK	15	15	14
H	14	14	13	13	21	21	UNK	UNK	UNK	UNK	UNK	UNK	21	21	13
A'	10	11	10	11	12	12	UNK	UNK	UNK	UNK	UNK	UNK	12	12	12
G'	13	14	14	14	15	15	UNK	UNK	UNK	UNK	UNK	UNK	15	15	14
H'	10	12	10	12	14	14	UNK	UNK	UNK	UNK	UNK	UNK	14	15	14

Table I - 15. Fireball Effects on Various Materials, Test 15

	Cloth												
	Green		White		Black		Cotton		Foam		Newspaper		Sand
Row	B	A	B	A	B	A	B	A	B	A	B	A	Bag
A	15	15	13	13	15	15	11	15	15	15	14	15	14
C	7	7	7	7	11	11	9	9	11	11	9	10	UNK
D	10	11	7	14	15	15	9	11	13	14	14	15	14
E	15	17	17	19	19	19	17	17	17	19	17	19	14
F	11	13	11	14	14	14	13	13	13	14	14	14	13
G	10	11	9	12	14	14	11	11	11	11	13	14	12
H	11	13	11	12	17	17	11	12	12	12	13	14	UNK
A'	8	8	10	10	13	13	10	10	10	14	11	14	12
G'	UNK	9	UNK	9	10	10	10	10	10	10	9	10	UNK
H'	UNK	8	UNK	8	15	15	13	13	15	15	15	15	UNK

Table I - 16. Fireball Effects on Various Materials, Test 16

	Cloth												
	Green		White		Black		Cotton		Foam		Newspaper		Sand
Row	B	A	B	A	B	A	B	A	B	A	B	A	Bag
A	15	17	15	17	17	17	17	17	17	17	19	19	15
C	11	12	11	13	13	13	11	13	13	13	10	12	12
D	10	11	7	7	11	11	12	12	12	12	13	13	UNK
E	9	12	9	10	10	10	10	10	10	10	9	11	UNK
F	11	11	8	11	14	14	12	12	12	12	12	12	12
G	11	11	11	11	11	11	12	12	12	12	12	12	UNK
H	7	7	UNK	7	17	17	9	9	13	13	13	13	UNK
A'	14	15	14	17	17	17	15	15	15	17	14	15	14
G'	11	14	12	13	14	14	15	15	15	15	15	15	
H'	13	14	10	14	14	14	13	13	13	13	13	14	14
D"	UNK	7	UNK	7	8	8							
E"	9	11	8	11	12	13							
F"	9	11	10	12	13	13							

Table I - 17. Fireball Effects on Various Materials, Test 17

	Cloth											
	Green		White		Black		Cotton		Foam		Newspaper	
Row	B	A	B	A	B	A	B	A	B	A	B	A
A	17	17	19	19	21	21	19	19	17	17	19	21
C	9	9	9	9	10	10	8	8	8	8	9	12
D	UNK	UNK	UNK	UNK	8	8	UNK	UNK	UNK	UNK	UNK	9
E	11	12	11	12	15	15	13	13	14	14	14	15
F	13	13	12	13	14	14	12	12	12	12	14	14
G	10	10	10	10	14	14	10	10	8	8	12	13
H	10	10	10	10	14	14	7	7	8	8	14	14
A'	12	12	12	12	14	14	14	14	11	11	14	15
G'	12	15	11	15	15	15	10	11	10	11	15	15
H'	15	17	14	19	19	19	17	17	15	15	19	19
D"	8	10	8	10	11	11	UNK	UNK	UNK	UNK		
E"	10	10	9	10	11	11						
F"	11	11	7	10	14	14	UNK	UNK	UNK	UNK		

Table I - 18. Fireball Effects on Various Materials, Test 18

	Cloth											
	Green		White		Black		Cotton		Foam		Newspaper	
Row	B	A	B	A	B	A	B	A	B	A	B	A
A	14	14	14	14	15	15	15	15	15	15	17	21
C	17	19	15	17	19	19	17	17	19	19	19	21
D	15	17	15	17	19	19	17	17	15	17	17	21
E	15	15	14	15	17	17	17	17	17	19	17	19
F	21	21	21	21	21	21	21	21	21	21	21	21
G	15	15	15	15	17	17	15	15	17	17	17	17
H	17	19	17	17	21	21	15	15	17	17	21	21
A'	UNK	UNK.	UNK	UNK.	UNK	UNK.	UNK	UNK.	UNK	UNK	UNK	UNK
G'	17	17	17	17	19	19	17	17	19	19	19	19
H'	10	12	12	13	13	13	13	13	13	13	13	13

Table I - 19. Fireball Effects on Various Materials, Test 19

Row	Cloth: Green B	Green A	White B	White A	Black B	Black A	Cotton B	Cotton A	Foam B	Foam A	Newspaper B	Newspaper A
A	13	13	13	13	14	14	13	13	15	15	15	15
C	10	10	9	11	13	13	11	11	11	11	11	14
D	14	14	13	13	15	15	15	15	15	15	15	17
E	14	14	11	11	15	15	10	11	13	13	15	19
F	15	15	15	15	17	17	14	14	15	15	15	19
G	9	10	11	11	13	13	13	13	13	13	14	14
H	17	17	21	21	21	21	19	19	17	17	21	21
A'	17	17	17	17	17	17	19	19	19	19	13	21
G'	10	10	12	12	13	13	13	13	12	12	13	17
H'	11	14	14	14	14	14	12	17	12	14	12	17
D"	12	12	10	10	13	13						
E"	14	15	14	15	17	17						
F"	11	14	13	14	14	14						

Table I - 20. Fireball Effects on Various Materials, Test 20

Row	Cloth: Green B	Green A	White B	White A	Black B	Black A	Cotton B	Cotton A	Foam B	Foam A	Newspaper B	Newspaper A
A	17	17	15	17	19	21	17	17	15	21	21	21
C	11	12	11	14	14	14	11	12	12	12	15	21
D	15	15	17	17	17	17	14	14	14	14	21	21
E	12	12	12	12	15	17	11	11	11	11	15	19
F	10	11	11	11	15	15	10	10	10	10	15	19
G	11	12	11	12	14	14	10	10	11	11	14	21
H	21	21	15	15	21	21	9	9	11	11	21	21
A'	12	12	13	14	17	17	11	11	13	13	14	17
G'	15	15	13	15	15	15	14	14	14	14	14	17
H'	9	10	9	10	12	12	10	10	10	10	12	17
D"	14	15	12	15	15	15						
E"	14	14	17	17	17	17						
F"	14	15	15	15	17	17						

Table i - 21. Fireball Effects on Various Materials, Test 21

	Cloth											
	Green		White		Black		Cotton		Foam		Newspaper	
Row	B	A	B	A	B	A	B	A	B	A	B	A
A	13	13	10	11	13	13	UNK	8	8	10	19	21
C	15	17	15	17	17	17	14	15	17	17	17	21
D	8	9	8	12	12	12	8	8	8	8	12	13
E	7	9	7	12	9	9	UNK	UNK	UNK	UNK	9	12
F	8	9	UNK	10	10	10	UNK	8	UNK	8	9	14
G	11	13	9	14	14	15	11	12	11	14	14	17
H	14	14	11	12	15	15	11	11	11	13	21	21
A'	17	17	13	17	19	19	13	15	15	21	21	21
G'	11	13	10	13	13	13	10	10	10	10	10	11
H'	12	12	8	10	15	15	10	10	11	11		
D"	9	13	9	14	14	14						
E"	11	12	9	14	14	14						
F"	12	14	11	14	15	15						

Table I - 22. Fireball Effects on Various Materials, Test 22

	Cloth											
	Green		White		Black		Cotton		Foam		Newspaper	
Row	B	A	B	A	B	A	B	A	B	A	B	A
A	17	19	21	21	19	21	17	17	13	15	17	21
C	15	19	15	19	19	19	17	17	17	17	15	19
D	14	17	15	17	17	17	17	17	17	19	15	19
E	19	19	19	19	19	19	15	17	17	19	17	21
F	19	21	21	21	21	21	17	21	21	21	21	21
G	17	17	17	17	17	19	15	15	15	15	19	21
H	21	21	21	21	21	21	21	21	21	21	21	21
A'	UNK	UNK	UNK	UNK	UNK	UNK	UNK	UNK	UNK	UNK	UNK	UNK
G'	8	8	8	8	9	9	9	9	8	9	9	10
H'	UNK	UNK	UNK	UNK	7	7	UNK	UNK	UNK	UNK	UNK	UNK
D"	NOT USED											
E"	NOT USED											
F"	NOT USED											

Table I - 23. Fireball Effects on Various Materials, Test 23

	Cloth											
	Green		White		Black		Cotton		Foam		Newspaper	
Row	B	A	B	A	B	A	B	A	B	A	B	A
A	14	15	13	13	15	15	15	15	15	15	15	15
C	17	17	17	17	17	17	15	17	17	17	17	19
D	14	14	15	15	15	15	15	15	15	15	15	15
E	10	12	11	12	12	12	12	12	11	11	11	14
F	15	15	15	15	15	15	15	17	17	17	17	17
G	10	10	9	11	11	11	11	11	10	11	11	12
H	8	8	8	9	10	10	9	9	8	11	UNK	12

Table I - 24. Fireball Effects on Various Materials, Test 24

	Cloth											
	Green		White		Black		Cotton		Foam		Newspaper	
Row	B	A	B	A	B	A	B	A	B	A	B	A
A	13	19	14	19	19	19	15	15	15	21	19	21
C	9	10	10	10	12	12	11	11	11	11	12	15
D	10	17	11	14	19	19	14	14	19	21	21	21
E	21	21	17	21	21	21	19	19	19	21	21	21
F	19	19	19	19	21	21	19	19	19	19	21	21
G	19	21	21	21	21	21	19	19	17	21	21	21
H	21	21	21	21	21	21	21	21	21	21	21	21
A'	9	9	9	9	10	10	10	10	9	9	10	13
G'	UNK	UNK	UNK	UNK	7	7	7	7	UNK	UNK	UNK	10
H'	UNK	UNK	UNK	11	11	11	UNK	UNK	UNK	UNK	9	9

APPENDIX II

PLOTS OF EFFECTIVE BURN AREAS

The plots of the effective burn area of each munition are shown in Figures II-1 through II-24.

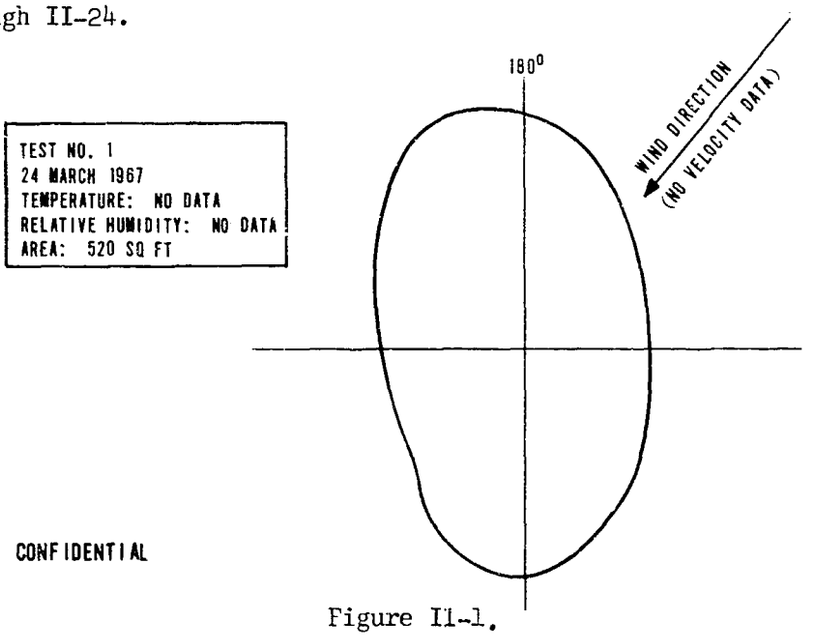
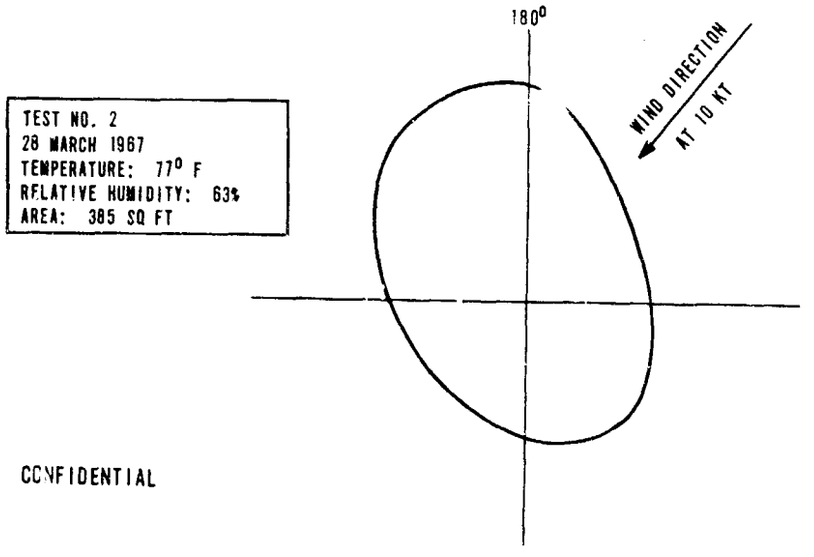


Figure II-1.



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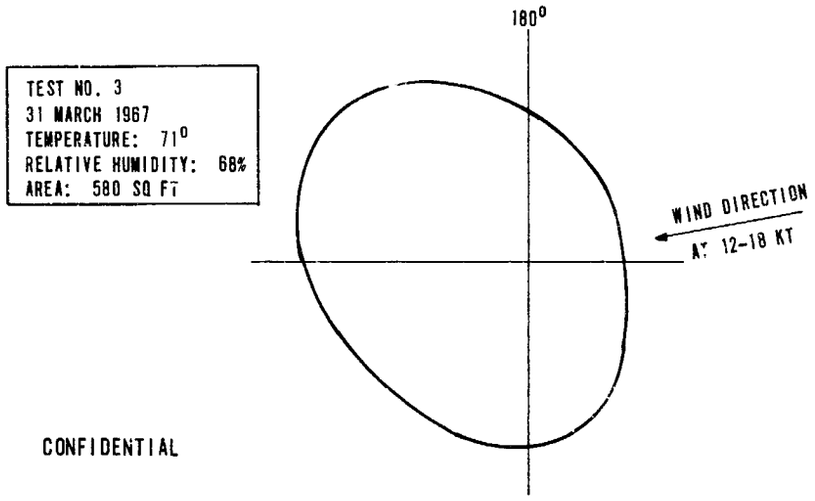

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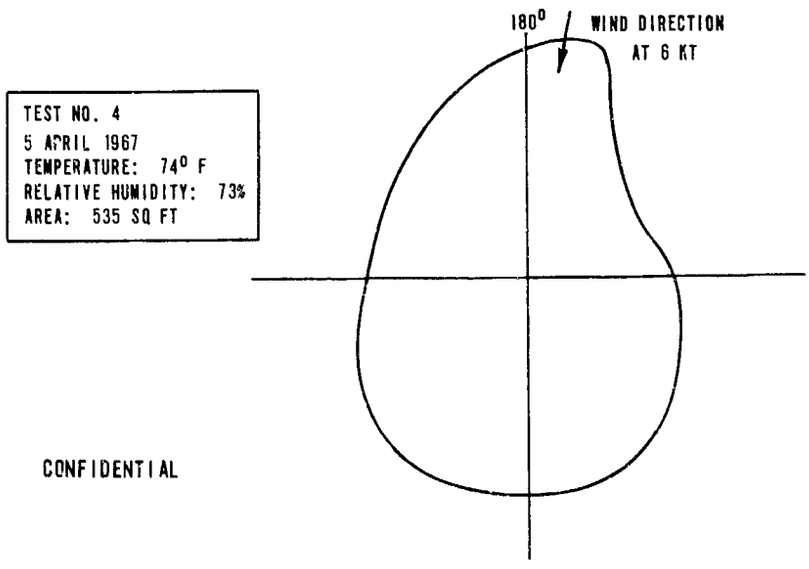

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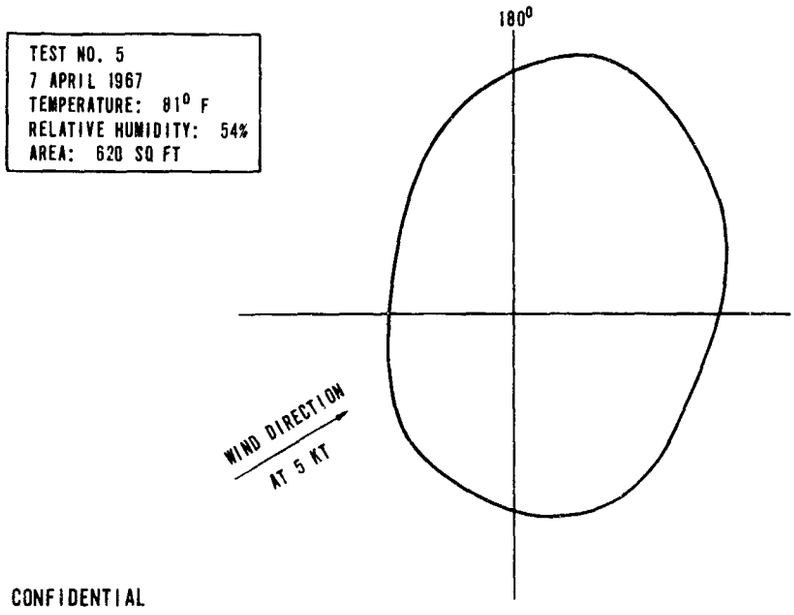

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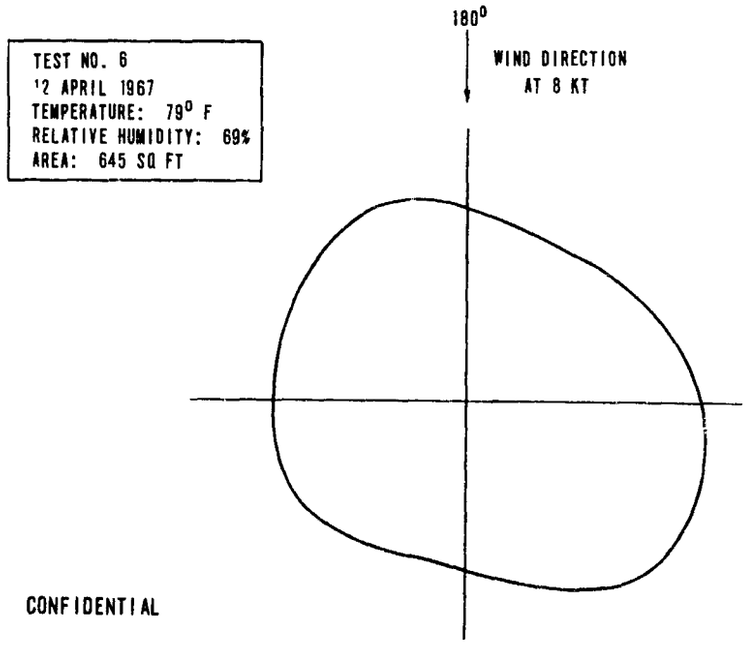

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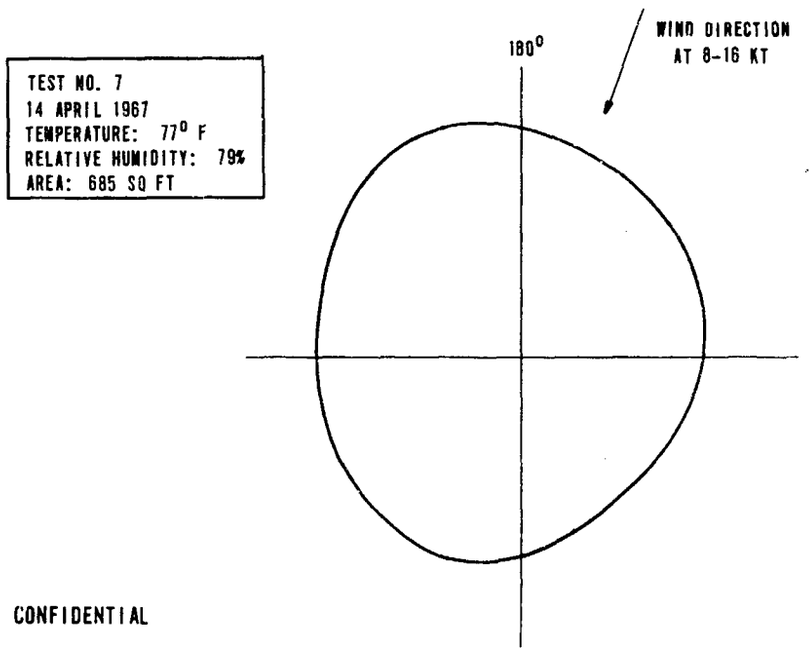

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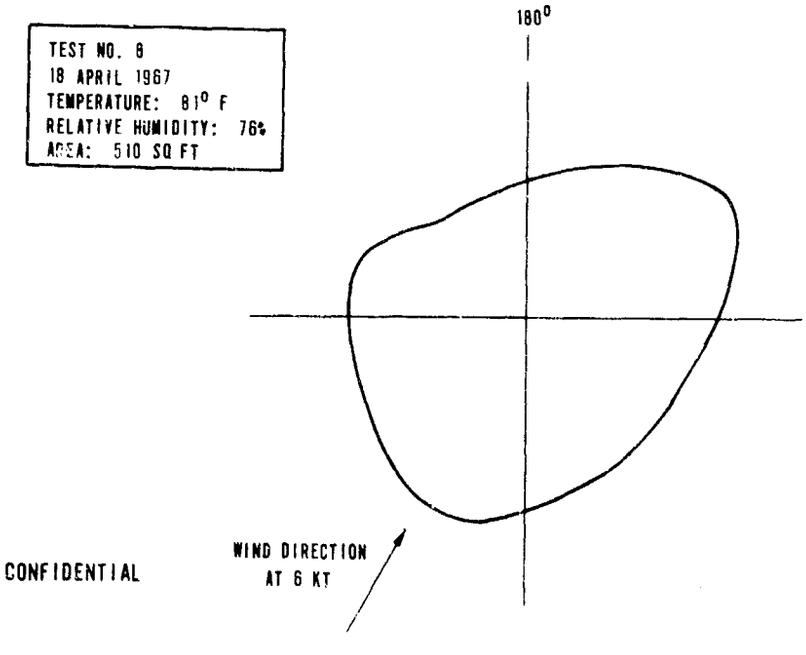

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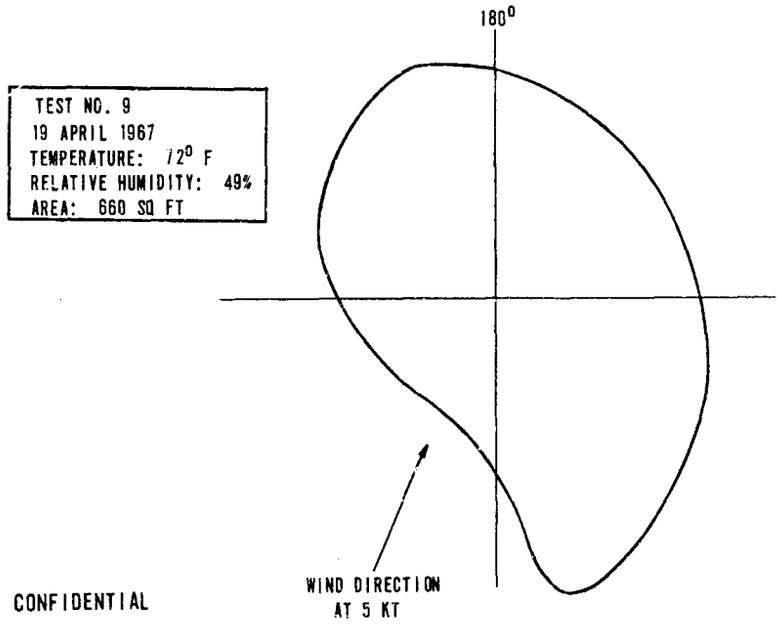

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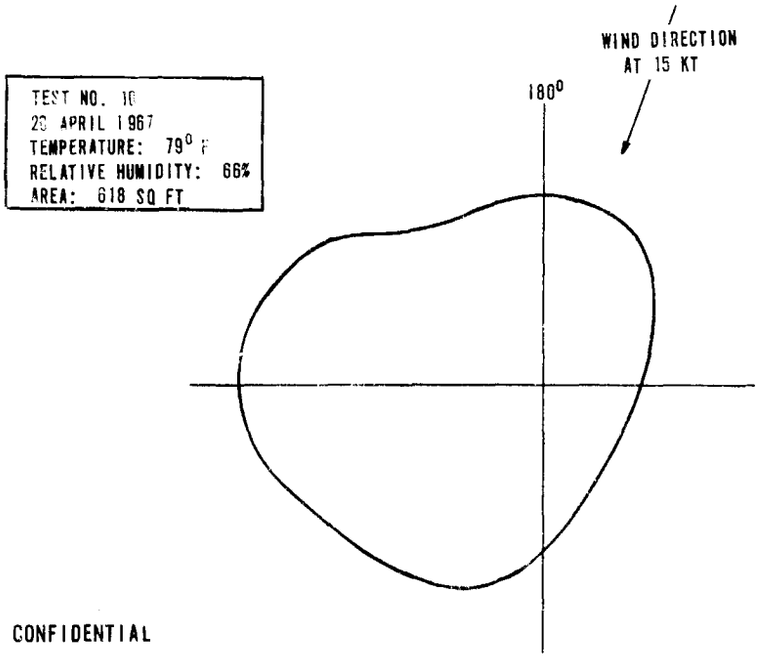

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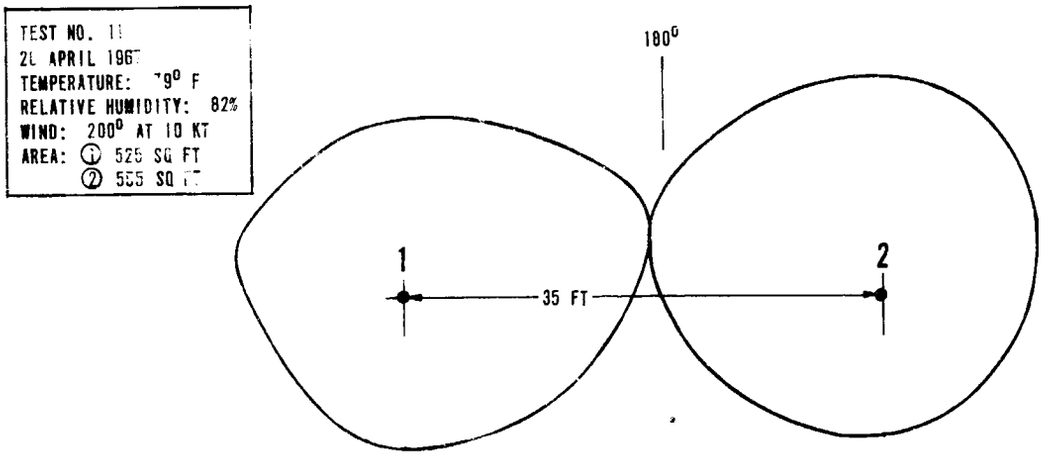

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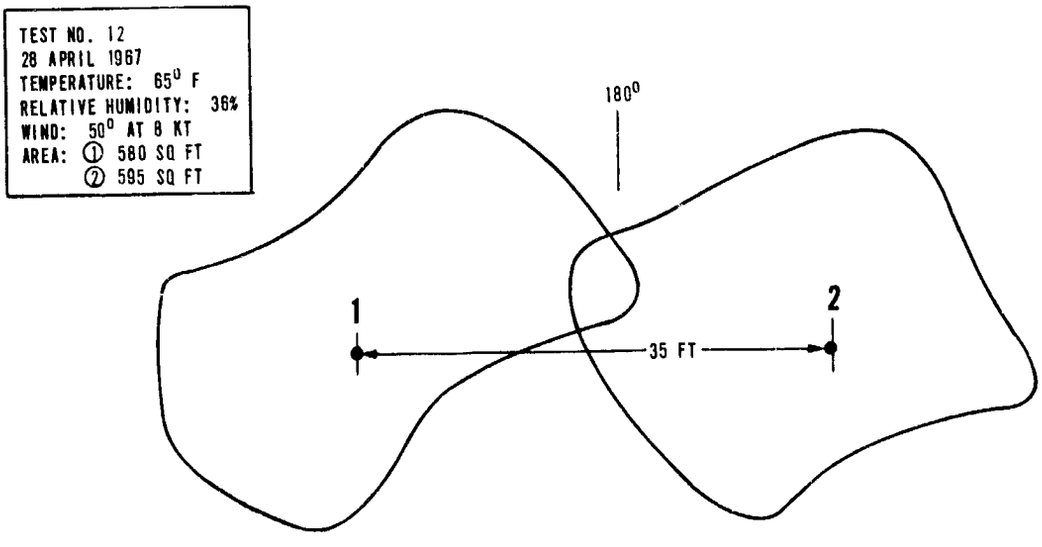

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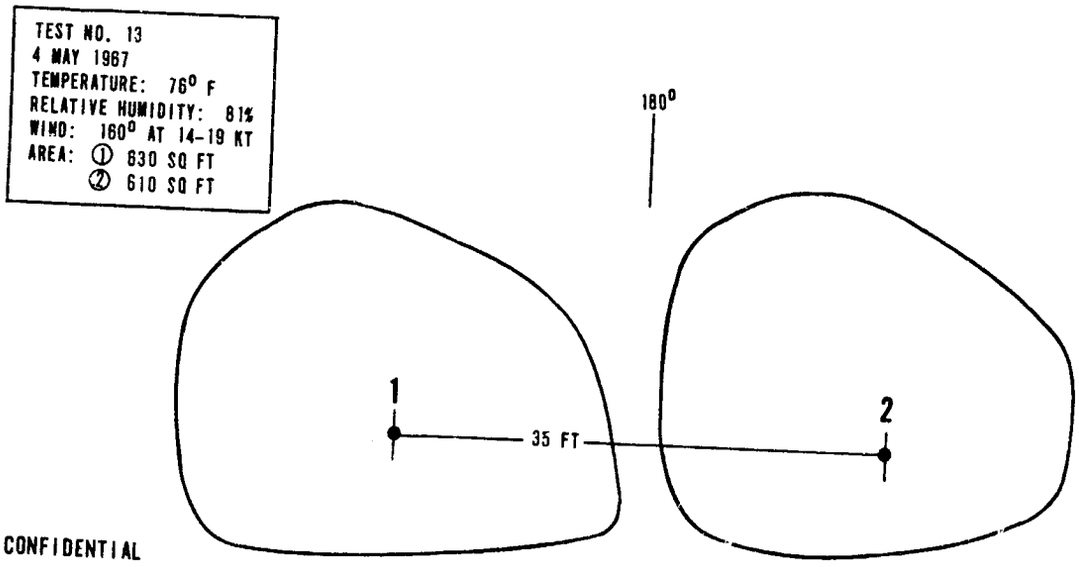

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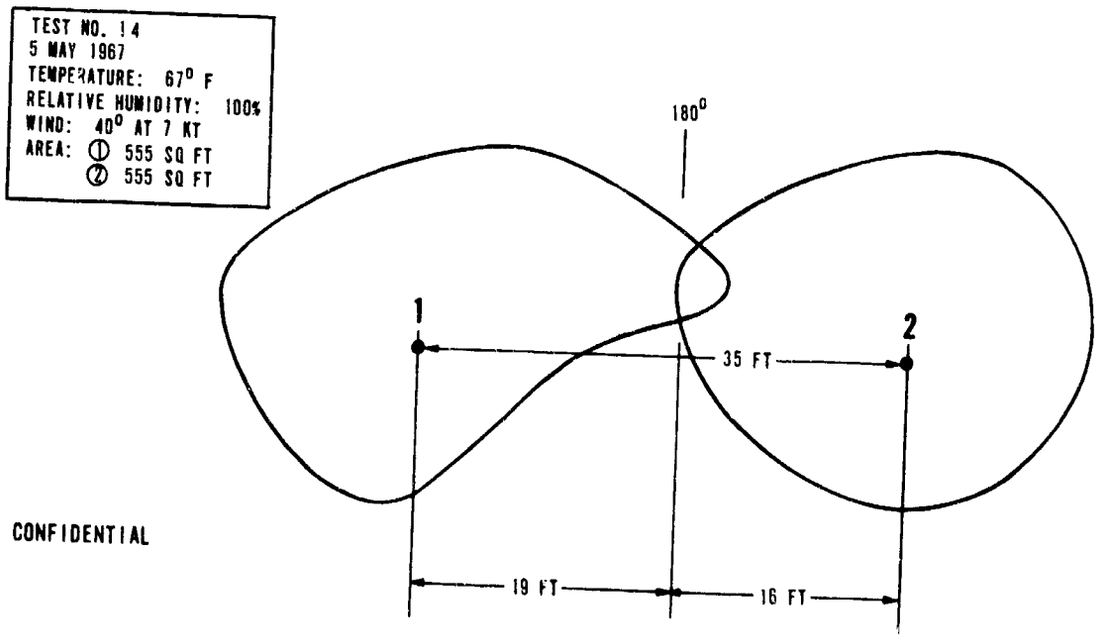

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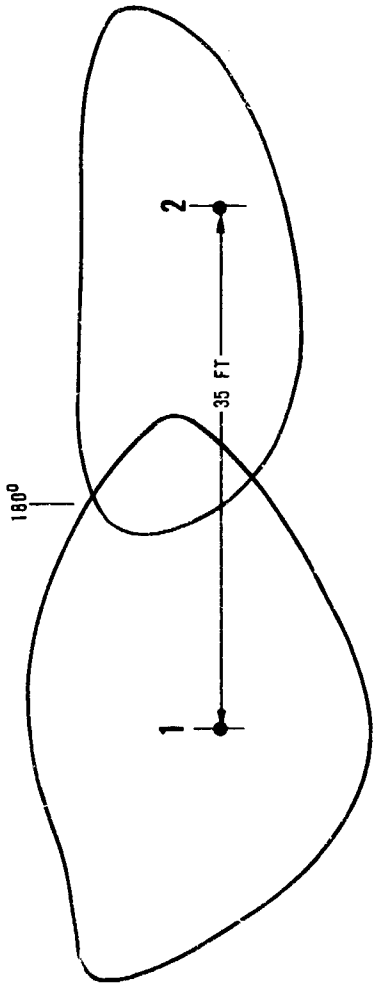

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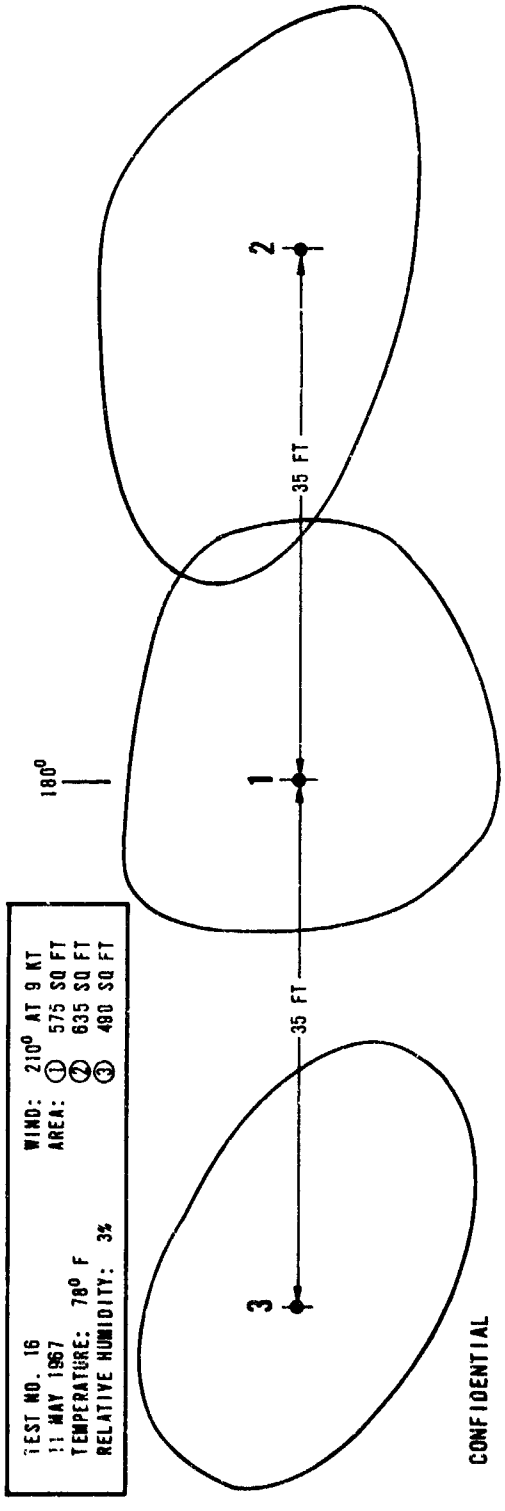

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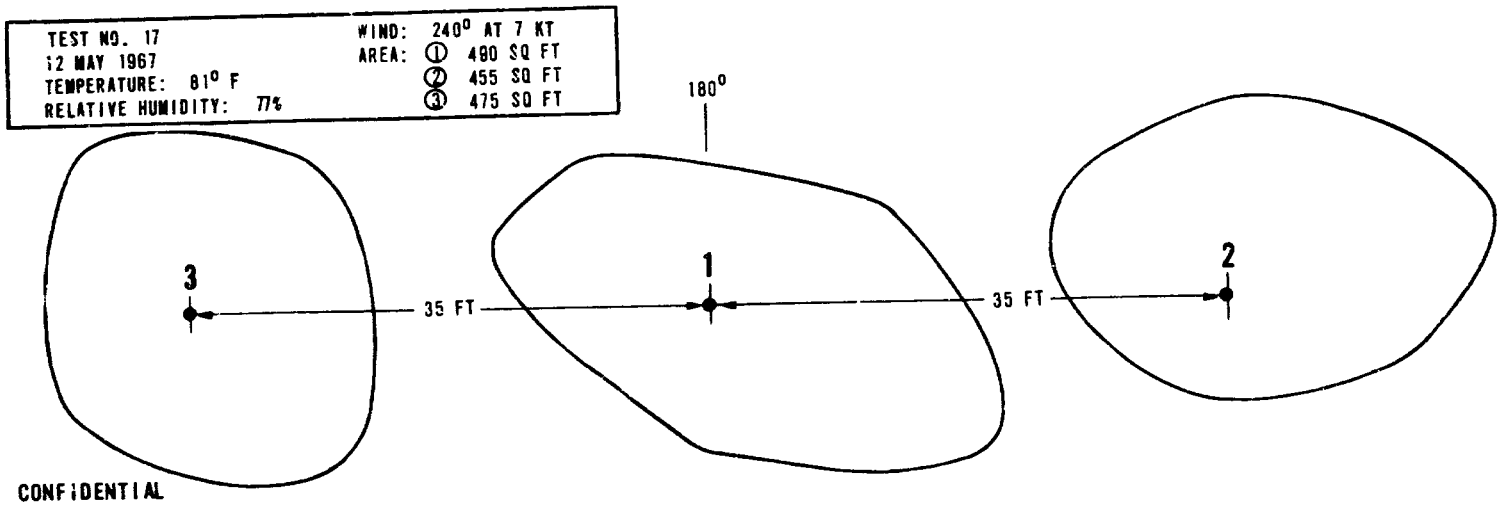

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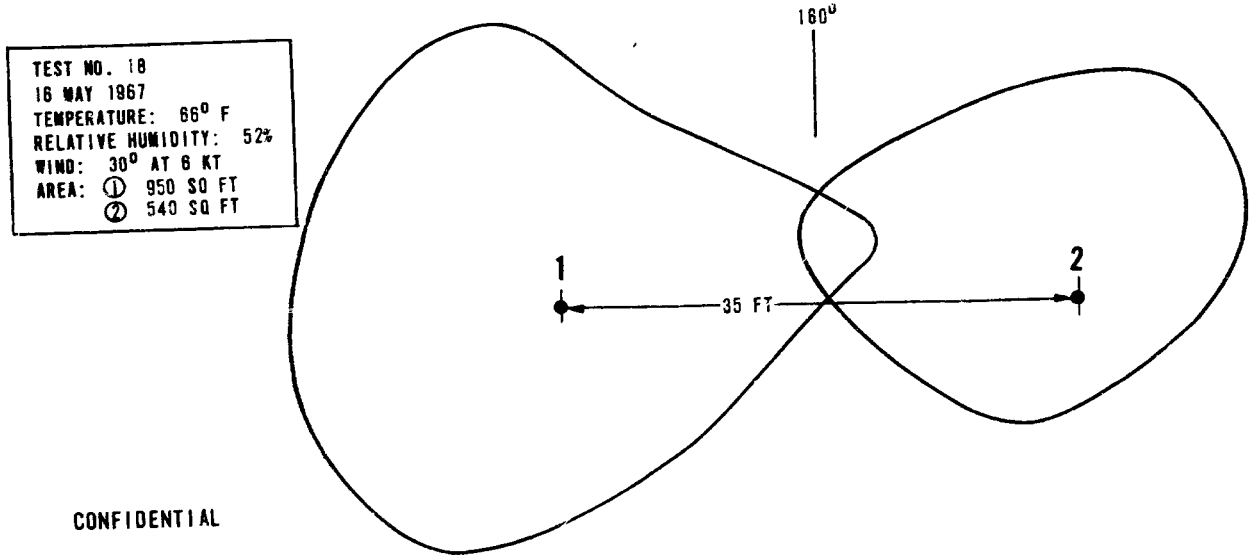

Figure II-18.

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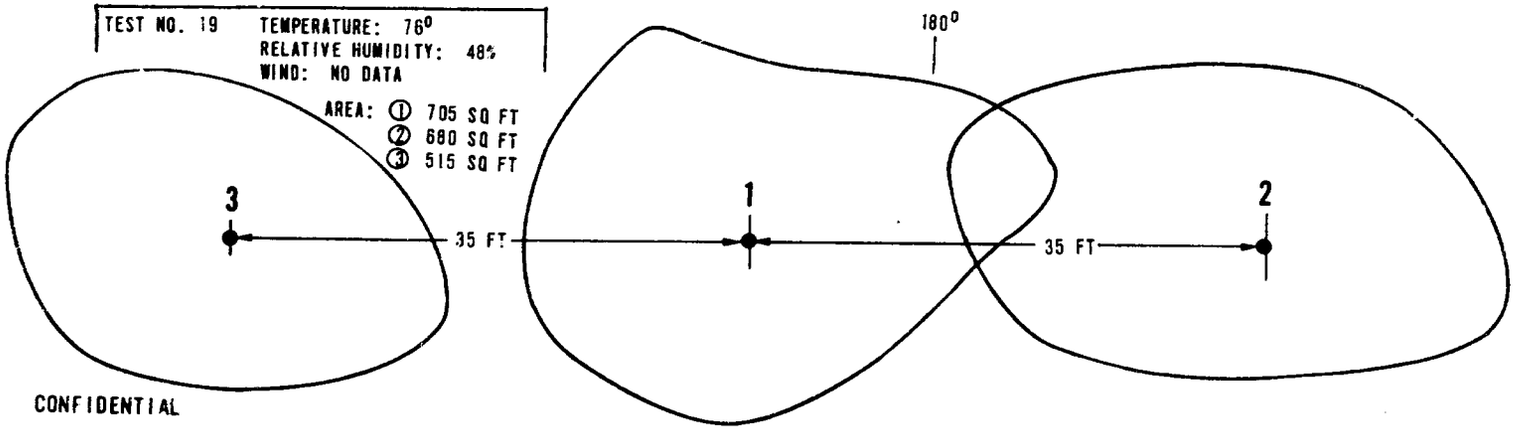

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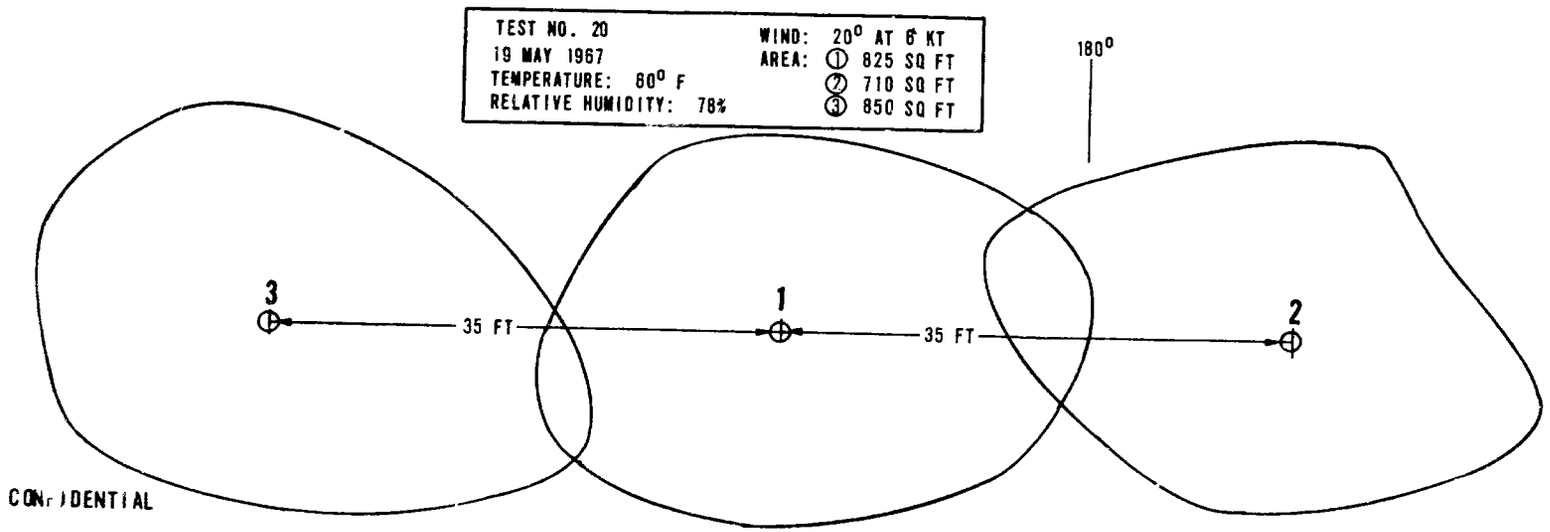

Figure II-20.

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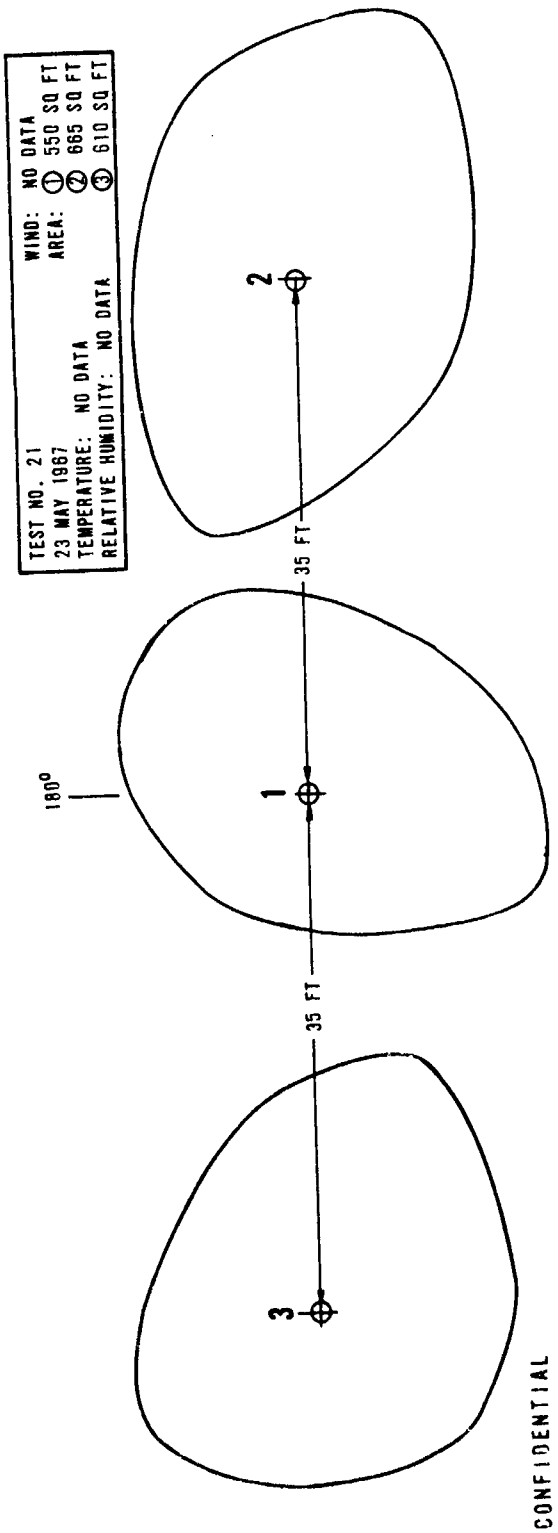
TEST NO. 21
23 MAY 1967
TEMPERATURE: NO DATA
RELATIVE HUMIDITY: NO DATA
WIND: NO DATA
AREA: ① 550 SQ FT ② 665 SQ FT ③ 610 SQ FT
180°
1
2
3
35 FT
35 FT
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Figure II-21.

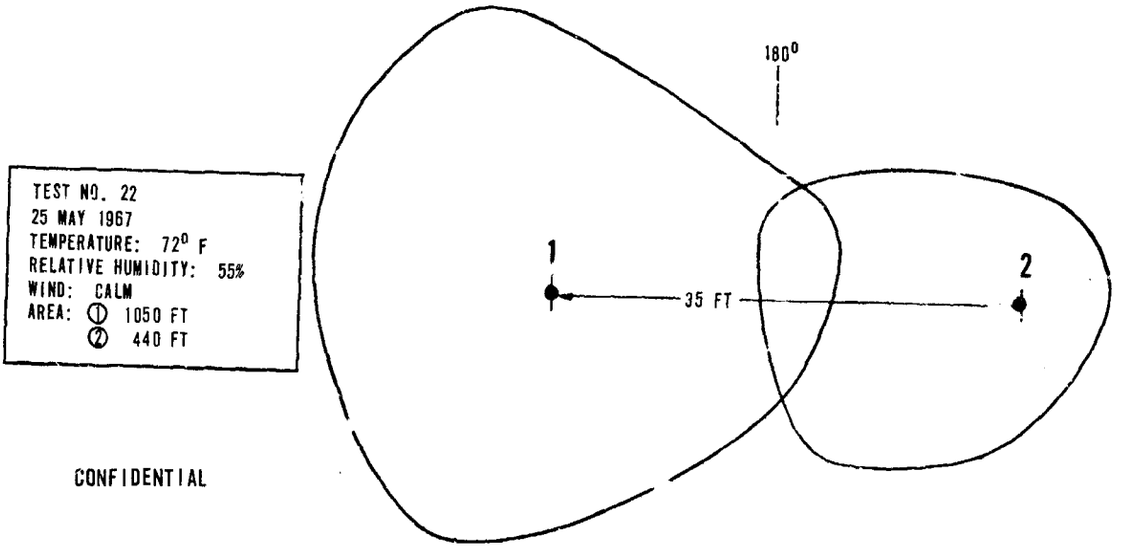

Figure II-22.

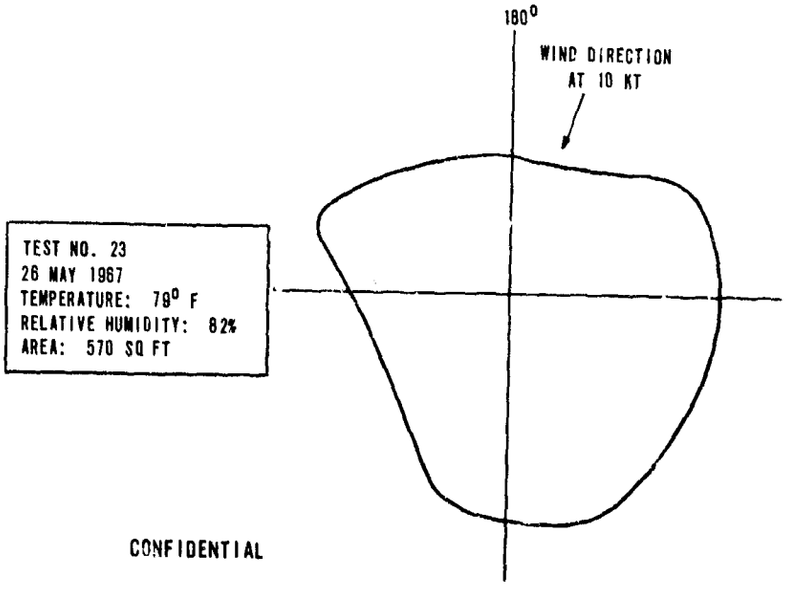

Figure II-23.

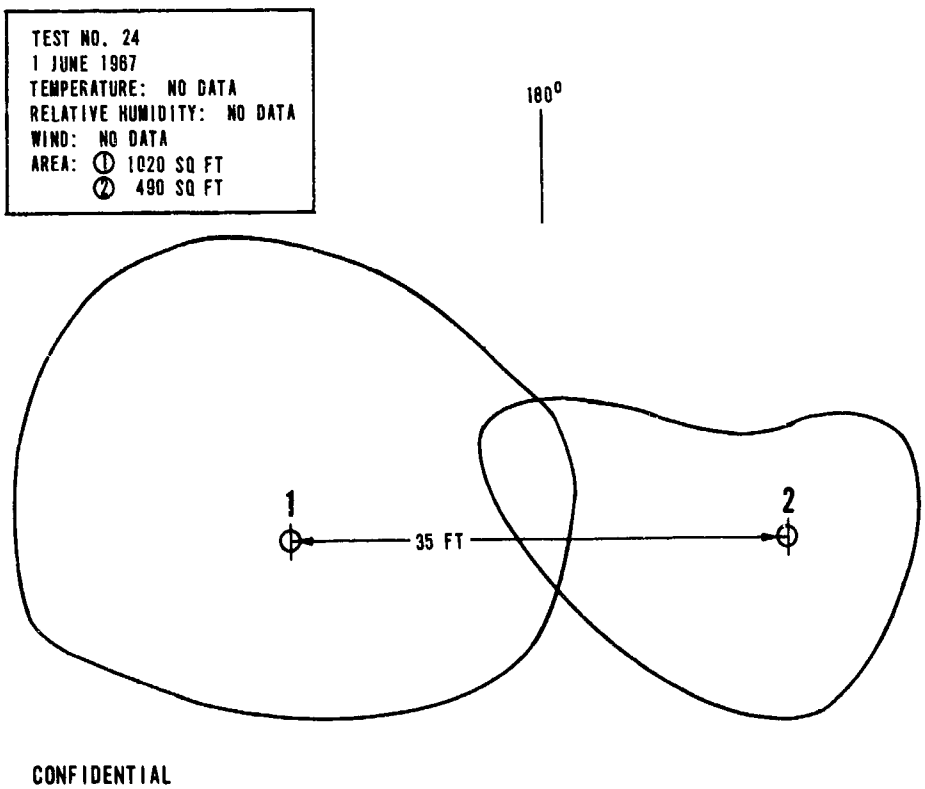
TEST NO. 24
1 JUNE 1967
TEMPERATURE: NO DATA
RELATIVE HUMIDITY: NO DATA
WIND: NO DATA
AREA: ① 1020 SQ FT
② 490 SQ FT
180°
1
2
35 FT
CONFIDENTIAL

Figure II-24.

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Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Air Proving Ground Center Eglin Air Force Base, Fla	2a. REPORT SECURITY CLASSIFICATION CONFIDENTIAL 2b. GROUP 4

3. REPORT TITLE
INDENDIARY EFFECTIVENESS TEST OF CHEMICAL FIREBALL MUNITION (U)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final Report (24 March 1967 - 9 June 1967)

5. AUTHOR(S) (Last name, first name, initial)
Kidd, John R. 2d Lt, USAF

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
September 1967	62	3

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 670AW40	APGC-TR-67-102
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. AVAILABILITY/LIMITATION NOTICES In addition to security requirements which must be met, this document is subject to special export controls, and each transmittal to foreign governments or foreign nationals may be made only with prior approval of the Air Proving Ground Center (PGO), Eglin AFB, Fla 32542.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Available in DDC.	Air Force Systems Command Andrews AFB, Wash D. C. 20331

13. ABSTRACT (C) This test was conducted to determine the incendiary effectiveness of the chemical fireball munition. A total of 48 munitions were tested. Eleven munitions were detonated singly, 10 in pairs, and 27 in triple firings. Thirty-nine munitions were detonated at ground level and seven were detonated 4 feet above ground level. Two munitions did not function. The chemical fireball munition caused burning effects on targets simulating personnel and equipment at an average distance of 15.68 feet from the point of detonation when detonated at ground level and 18.08 feet when detonated 4 feet above ground level. This difference is statistically significant at a 99 percent confidence level. The average effective burn area for 32 separate chemical fireball munitions detonated at ground level was 557.9 square feet. The average effective burn area for seven separate chemical fireball munitions detonated 4 feet above ground level was 699 square feet. Effective burn areas are illustrated for each test. Data on thermal radiation for the single firings are included.

DD FORM 1 JAN 64 1473

CONFIDENTIAL (Gp-4)

Security Classification

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Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Thermal radiation Antimaterial Antipersonnel Incendiary bomb Flash blindness Flash burn						

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